AD-A054 630 BOOZ-ALLEN AND HAMILTON INC BETHESDA MD F/G 15/5

DEVELOPMENT OF A LOGISTICS PRICE FILE.(U)

OCT 77

UNCLASSIFIED NL

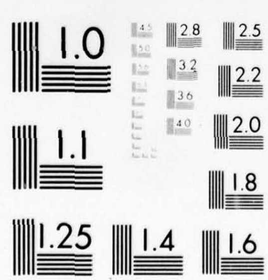
1 OF 3

AD A054630

ASSIFIE

1 OF 3

AD
A054630



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

6 Development of a logistics price file.
~~Technical Report~~.

5. ~~TYPE OF REPORT & PERIOD~~ COVERED

9 Final rep[redacted]t.

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Booz-Allen & Hamilton, Inc.
4330 East West Highway
Bethesda, Maryland 20014

10. PROGRAM ELEMENT, PROJECT, TASK AREA & ~~WORK UNIT NUMBERS~~

12 194p.

11. CONTROLLING OFFICE NAME AND ADDRESS

U.S. Army Engineer Division, North Central
536 S. Clark St.
Chicago, Illinois 60605

11 ~~12. REPORT DATE~~

31 Oct [redacted]77

~~13. NUMBER OF PAGES~~

191

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)

Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release. Distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

U.S. Ship traffic
Canadian ship traffic
Traffic forecasts
Computer models
Mode splits

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The U.S. Army Corps of Engineers, North Central Division, maintains a Route Split Model for forecasting projected traffic on the Great Lakes/St. Lawrence Seaway System. This model allocates cargo on the basis of determined shipper sensitivities to various service and cost factors. The Logistics Price File data base contains all the freight rate data required to allocate rate-sensitive traffic to either a Great Lakes or a competitive route. The Technical Report describes and documents the study approach. The first phase was development of a rate calculator model capable of producing any land or water freight rate based on

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED 408 597

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. (cont'd)
the origin and destination points and commodity characteristics. The second phase involved developing techniques to produce through rates compatible with the geographic and commodity specifications of the Route Split Model. The rate calculator model develops the level of freight rates from regression analysis of actual freight rates. The most significant variables or factors are distance, stowage factor, value per ton, ocean conference, and rail rate territory.

FOR FURTHER TRAN

12

AD A054630

October 31, 1977

DDC
RECEIVED
JUN 2 1978
F

DEVELOPMENT OF A
LOGISTICS PRICE FILE

TECHNICAL REPORT

for

U.S. Army Corps of Engineers

AD No.
DDC FILE COPY

BOOZ · ALLEN & HAMILTON Inc.
Management Consultants

4330 EAST WEST HIGHWAY
BETHESDA, MARYLAND 20014
951-2200
AREA CODE 301

TABLE OF CONTENTS

I. STUDY OVERVIEW

I. STUDY OVERVIEW

1. INTRODUCTION

The U.S. Army Corps of Engineers maintains a Route Split Model (RSM) to predict the flow of commodities within the Great Lakes/St. Lawrence Seaway system. The model is a tool for forecasting projected traffic on the system attributable to alternative system improvement programs.

The three principal data inputs to the model are:

- Forecasts of the potential flow of commodities into and out of the Great Lakes "hinterland"
- Service attributes of Great Lakes and competitive routes
- Cost attributes of Great Lakes and competitive routes

The commodity flow forecasts identify all movements which may have an origin or destination in the Great Lakes hinterland, which is the geographic area served by the Great Lakes system. The model uses the service and cost attributes above to allocate those flows to either a Great Lakes or an alternative routing.

The cost data base, noted above, is referred to as a Logistics Price File. This data base contains all the freight rate data required to allocate rate-sensitive traffic to either a Great Lakes or a competitive route. The development of the Logistics Price File (LPF) is documented in a two-volume report. The first volume, the Executive Summary, provides an overview of the:

- Structure of the LPF
- Study approach
- Validation techniques
- Study conclusions

This volume of the final report, the Technical Report, describes the study approach in detail and documents the development of all rate information.

The remainder of this chapter provides a summary of the framework of the study, and an introduction to terminology used in the remainder of the report.

2. STRUCTURE OF THE LPF

In this section the structure of the LPF is summarized, and the basic geographic and commodity units used in the Route Split Model are identified. It was necessary to maintain the geographic and commodity units of the RSM in the LPF in order to provide complete compatibility between the LPF and the model itself.* Terminology defined below to describe the LPF is used throughout the remainder of the report.

(1) Commodity Units

The basic commodity unit in the model is a commodity family. Every commodity potentially moving within the Great Lakes has been classified into one of 37 families. These families are identified in Appendix A of the Technical Report. There are 22 bulk families; the major bulk families are homogeneous. There are 15 general cargo families, all of which are diversified.

(2) U.S. Origins and Destinations

General cargo origins and destinations (O/D's) are defined in terms of 19 hinterland States. Bulk cargo O/D's are identified by BEA's.** The prime hinterland is assumed to consist of 84 BEA's. In addition, the fourteen BEA's which border the Great Lakes directly were subdivided further to twenty sub-areas, producing a total of 90 primary inland O/D's. A limited number of movements involve 99 other BEA's outside the prime hinterland.

---

* This compatibility was required because the Route Split Model became operational in early 1976, while this study was conducted more than a year later. Development of a structurally different LPF would have required substantial modification to the Route Split Model.

** Economic areas defined by the U.S. Department of Commerce, Bureau of Economic Analysis. In this system the entire continential U.S. is divided into 171 BEA areas.

(3) Canadian Origins and Destinations

Eleven areas in Canada which border on the Great Lakes are identified in the commodity forecasts. In the RSM Canadian origins and destinations are not traced inland beyond these lakeside areas.

(4) Overseas Regions

Foreign trade is defined in terms of nineteen trade regions. These regions and the regions described above are given in Appendix B of the Technical Report.

(5) The "ODC" Concept

The commodity flow forecasts of the RSM are expressed in terms of the geographic and commodity units given above. A potential flow is defined by its origin area, destination area and commodity family. This flow is therefore referred to as an "ODC". There are 6852 ODC's with cargo in the RSM;* competitive rate information was required for these ODC cells.

Sample ODC's are shown in Table I-1 below.

TABLE I-1
ODC Definition

	Origin (O)	Destination (D)	Commodity (C)
Bulk:	BEA 68	BEA 72	Iron Ore
	BEA 68	BEA 76	Iron Ore
General Cargo:	Illinois	Northern Europe	Steel products
	Ohio	Northern Europe	Steel products
	Ohio	Northern Europe	Electrical machinery

Note: Each of the five combinations above forms an "ODC" (Origin, Destination, Commodity)

* There are more than 2 million theoretical ODC combinations.

(6) Potential Routes and Component Routes

Table I-2 summarizes the different types of routes for which rate information was developed. As shown in the Table, one ODC (e.g. domestic bulk) may require as many as six cost elements, including three freight rates. Table I-3 illustrates the approximate number of component freight rates (excluding terminal charges or Seaway tolls) which were calculated in order to fill the 6852 ODC cells.

3. SUMMARY OF APPROACH

The basic methodology for providing the 17,000 through rates required to complete the LPF involved two principal phases. The first phase was development of a rate calculator model capable of producing any land or water freight rate based on the origin and destination points of the movement and the characteristics of the commodity. This model consists of a series of rate calculator equations developed by regression analysis of approximately 2000 actual freight rates. These equations are supplemented with a file of rates for a limited number of movements which were not subjected to statistical analysis. The second phase of the approach involved developing techniques to use the rate calculator model to produce through rates compatible with the geographic and commodity specifications of the RSM and reflecting current cost differentials for competitive routes. Key elements of this two-phase approach are described below.

(1) Rate Calculator Model

The rate calculator model will estimate the freight rate for any commodity movement potentially involving the Great Lakes system. Rates for a commodity are provided for all modes of carriage normally used to transport that commodity.

An important factor influencing the level of freight rates is shipment size. Normally per unit rates decrease as minimum lot sizes increase. Table I-4 summarizes the modes and shipment sizes for which the model will produce overland freight rates.

TABLE I-2
RSM Route and Cost Elements

Cargo	Movement	Route	Inland Transport Charges to Port*	Terminal Charges	Waterborne Costs	Seaway Tolls	Terminal Charge	Inland Transport Charges to Dest.**	No. of ODC's
General	Overseas	G.L.	●	●	●	●			1710
		Comp.†	●	●	●				
	Lakewise	G.L.	●	●	●	o	●	●	185
		Comp.						●	
Bulk	Overseas	G.L.	o	o	●	●			3433
		Comp.†	●	●	●				
	Lakewise	G.L.	o	o	●	o	o	o	1524
		Comp.						●	
									6852

Key: ● Always required
o Sometimes required depending on origin or destination

"G.L." is Great Lakes route
"Comp" is competitive route

* For overseas movements this rate component represents the overland movement between a U.S. or Canadian point and the port of loading (exports) and unloading (imports).

** Direct haul from origin to destination.

† The competitive overseas routes analyzed involved U.S. and Canadian ocean ports.

TABLE I-3
LPF Component Rates

Cargo	Movement	Route	Mode	No. of ODC's	Average No. of Rates Per ODC*	Component Rates	No. of LPF Records**
General	Overseas	G.L.	BB	1710	2	3420	1710
			CTR		2	3420	1710
		COMP	BB		2	3420	1710
			CTR		2	3420	1710
	Lakewise	G.L.	BB	185	1.5	278	185
			CTR		1.5	278	185
		COMP	BB		1	185	185
			CTR		1	185	185
Bulk	Overseas	G.L.		3433	1.5	5150	3433
		COMP			2	6866	3433
	Lakewise	G.L.		1524	1.5	2286	1524
		COMP			1	1524	1524
				6852		30432	17494

Abbreviations:
- G.L. is Great Lakes route
- COMP is competitive route
- BB is break bulk rate
- CTR is container rate

---

* Estimated

** Machine readable card images

TABLE I-4
Mode and Shipment Size
(Overland Rates)

Commodity Group	Mode	Shipment Size
Grains	Rail	Single carload Multiple car/unit train*
	Truck	Truckload
	Barge	-
Coal***	Rail	Multiple car/unit train**
Iron ore	Rail	Multiple car/unit train*
Other dry bulk	Rail	Single carload
General Cargo (Break Bulk and containerized)	Rail	Single carload
	Truck	Truckload/trailerload

* Lowest prevailing multiple car rate is applied on a route-specific basis. If no multiple car rates are available single car rates are used.

** Multiple car rates are applied on a regional basis.

*** Barge transport is not a feasible mode for any coal movements identified in the Route Split Model.

The lakewise water rates produced by the model reflect vessel sizes normally used to transport each commodity. For iron ore, coal, limestone and grain the rates correspond to lakewise bulk carriers of 20,000-30,000 DWT. Other dry bulk rates correspond to a self-unloading vessel of about 11,000 DWT. Tanker rates correspond to Great Lakes tankers of 3,000-4,000 DWT. With the exception of some container traffic, ocean freight rates are not normally quoted as a function of shipment size. Container rates reflect full containerloads.

As indicated above, the model produces overland rates for competing modes over the same overland routes.

The method for selecting the rate and route for a commodity movement is summarized in the section below.

(2) <u>Route Split Model Rates</u>

The rate calculator model will produce a rate for a specific commodity over a specific route. This section summarizes the method used to produce rates which are compatible with the geographic areas and commodity families of the RSM.

The RSM rates developed for general cargo are weighted average rates which reflect the least cost through rate for a Great Lakes and for a competitive route. Development of weighted average rates required the following steps:

- <u>Define commodity family profile</u>. A mix of specific commodities for each hinterland state, commodity family and direction were developed.

- <u>Define geographic profile</u>. Production and market areas within each state were identified.

- <u>Postulate Great Lakes and competitive routes</u>. For each inland O/D city, natural tributary ports on the Great Lakes with general cargo facilities were identified. For overseas cargo, rates through ocean ports in six coastal ranges were calculated. (A through rate includes overland haul, terminal charges at the port and ocean freight.) The six coastal ranges include:

    - North Atlantic
    - South Atlantic
    - South Florida*
    - Gulf
    - Pacific
    - Canadian Atlantic

  For the overland component rate both truck and rail costs were calculated and the lower cost was used. The through rate for a

---
* Non-conference carriers operating between Miami and the Caribbean and Central America.

competitive route used in the weighting calculation below was the lowest rate selected from the six alternative ocean port routings identified above.

- Calculate weighted average rates. For one ODC the approach above will produce several through rates for each combination of inland city and specific commodity. A weighted average rate for the ODC was calculated to reflect this rate distribution.

Weighted rates were not calculated for bulk commodities because bulk commodity families and interior origins and destinations (BEA's) are relatively homogeneous. The limited heterogeneity of a few families was represented by weighted average commodity characteristics (stowage factor and value per ton). Thus bulk RSM rates correspond to point-to-point movements of specific commodities.

For each bulk commodity family a representative production city and market city was identified in each BEA. Natural tributary lake ports were identified for each such city. For a given routing the costs for alternative modes (rail, truck, barge, or pipeline if appropriate) were calculated and the least cost mode was used.

Several considerations shaped the approach above for developing Route Split Model rates, including:

- Freight rates are quoted for point-to-point movements of specific commodities, and are not directly related to the geographic areas and heterogeneous commodity families of the RSM.

- The large number of freight rates required (more than 30,000 overland and waterborne rates were entered into the LPF) rendered an individual fill-in approach infeasible.

- Satisfying the rate requirements of the RSM required only the establishment of relative rate advantages for competitive routes and not necessarily an extensive file of absolute rates.

The approach taken in this study reflects a compromise between the absolute accuracy of rate quotations and the extensive geographic and commodity diversification of the RSM.

The remainder of this volume is organized into four chapters and several data appendices. Chapter II documents the development of the rate calculator model. In Chapter III the methodology for using the model to produce RSM rates is described. Chapter IV describes validation tests which were applied to the products of the study, and provides observations concerning applications of the LPF. Chapter V recommends a methodology for updating the LPF.

II. DEVELOPMENT OF THE RATE CALCULATOR MODEL

II. DEVELOPMENT OF THE RATE CALCULATOR MODEL

This chapter describes the development of a model which will calculate overland and waterborne freight rates. The rate specifications required for input to the model include the origin and destination points and the characteristics of the commodity. The rate calculator model has been used to calculate all the specific freight rates necessary to define each ODC rate.*

The model consists of two principal parts:

- A set of rate calculator equations, which are used to produce complete ODC rates for most commodities and movements

- A file of actual freight rates which are used directly for component rates or complete ODC rates for selected movements.

In general, actual rates rather than calculator equations are used in the model for small groups of ODC's which have unique rate properties, or whenever the rates for certain commodity movements did not prove susceptible to statistical rate analysis. This compilation of actual freight rates included the following commodities and movements:

- All iron ore movements

- Grain movements by barge or multiple car/unit train

- Lakewise water movements of grain, coal, and limestone

A complete description of these rates with tariff citation has been submitted under separate cover to the North Central Division, U.S. Army Corps of Engineers. The remainder of this chapter is devoted to a description of the methodology used to develop the rate calculator equations.

---

* An ODC rate is the total transport cost for an ODC of the Route Split Model.

1. THE GENERAL STRUCTURE OF THE RATE CALCULATOR EQUATIONS

Several quantifiable factors may influence the level of overland or waterborne freight rates. The three principal factors used in this analysis were the distance of the movement, and the density (or stowage factor) and value of the commodity. The first two factors are the most important factors contributing to the carrier's cost of providing the transportation service; the last factor is a measure of the value of the service. Many other factors influence freight rate levels, including cost factors such as availability of backhaul and overall equipment or vessel space utilization, and market factors such as level of competition and service considerations.

Previous research has been conducted which attempted to establish the relationships between rate levels and movement characteristics. The results of that research, as it provided guidance within this study, are summarized in the subsection below. The next subsection identifies all the factors or variables used in the rate calculator equations, and describes the mathematical form of these equations.

(1) Summary of Previous Research

1. Ocean Freight Rates

In a recent study Shneerson* determined that stowage factor was the most significant factor for explaining the level of freight rates. The importance of stowage factor did not vary with voyage length or with vessel utilization for each leg of the voyage.

Unit value was positively correlated with rate but is less significant in highly competitive situations. Logarithmic functions of dependent and independent variables provided the best curve fit.

Carman** evaluated a large number of explanatory factors and concluded that stowage factor and

---

* O. Shneerson, "The Structure of Liner Freight Rates, A Comparative Route Study." Journal of Transport Economics and Policy, January 1976, pp. 52-67.

** James R. Carman, "Analysis of Ocean Freight Rates by Multiple Regression." Transportation Research Forum, pp. 433-450.

value were most significant. He achieved an r^2 of only 0.45 using these variables, probably in part because his regressions were limited to linear relationships.

An analysis involving all segments of the ocean transportation industry (liner, bulk, tanker and neobulk) was performed by Lipsey and Weiss.* They defined freight rate as the difference between c.i.f. value and f.o.b. or f.a.s. value as reported in Census statistics. Using logarithmic relationships a correlation of $r^2=0.80$ was achieved with value per ton, distance and stowage factor as the explanatory variables. The analysis showed a weak indication that the cost of liner transportation was comparatively higher than bulk or neobulk and that higher utilization outbound led to lower freight rates inbound.

Heaver** analyzed ratesetting in a conference environment involving trade between the U.S. Pacific Coast and Japan and Australia. Based on linear regression analysis he determined that stowage factor, value per ton, and total value of trade by commodity and direction were the most significant determinants of rate levels.

A pilot study by OECD*** found in a sample of total transportation costs between the U.S. and North Europe that there were no systematic difference in ocean freight charges to Europe as a function of sea distance. The proposed explanation was that a relatively small part of total liner cost is a function of the sea distance. The cost of loading and discharge of the vessel and other port related charges were more important, and differences in these items outweigh the influence of even great differences in sea transport distance.

---

* Robert E. Lipsey and Merle Yahn Weiss, "The Structure of Ocean Transport Charges." Explorations in Economic Research, Vol. 1, No. 1. Summer 1974, pp. 162-193.

** Trevor D. Heaver, "The Structure of Liner Conference Rates." Journal of Industrial Economics, Vol. 21, July 1973, pp. 257-265.

*** Ocean Freight Rates as Part of Total Transport Costs, Organization for Economic Cooperation and Development, Paris, 1968.

Katz* has proposed that freight rates seek a level somewhere between the marginal cost of handling the cargo as a lower limit and an upper limit set by the value to the shipper of service provided. Low value cargoes, which will be sensitive to transportation cost, will tend to be rated near the lower limits. Movement of high value cargoes, for which transportation charges will be a very small portion of the overall cost of the commodity, will be insensitive to a higher freight rate. The freight rates for these cargoes will be set near the higher limit. Katz presented no empirical evidence to prove his hypothesis, however.

2. Overland Freight Rates

Several ICC Dockets have established strong relationships between rail rates and costs. If this relationship is true, distance and stowage factor should exhibit a strong correlation with rail rates.

A comprehensive overview of the history and present status of ratemaking in the railroad industry is presented by Zeis.** The railroads compete primarily with trucks, barges, pipelines and intercoastal liners. Competition is identified as an important determinant of rates, and consequently variation of rate with commodity and geographic area is to be expected.

A significant trend in historic rail rate levels, according to Zeis, is equalization of rates over distance. This trend, called market equalization, means that cargoes moving over short distances compete in the same market with cargoes moving over longer distances.

Edwards*** has hypothesized a cross-subsidization in railroad ratemaking. According to this theory, high value cargo is assessed relatively high rates so that high value commodities offset more than their share of costs.

---

* Harold Katz, Steamship Conferences and Ocean Rate Making, Columbia Journal of World Business, Spring 1976, pp. 23-31.

** P.M. Zeis, Competitive Rate Making in the United States. Transportation Journal. Vol. 8. Summer 1969, pp. 34-42.

*** F.D. Edwards, The Role of Transportation Costs and Market Demand in Railroad Rate Making. Transportation Journal, Vol. 9, Fall 1969, pp. 45-50.

Mattox and Marien* advocate the familiar concept of formula rates. They argue that the origin of most rail rates was a rate calculation formula, and that differential adjustments and rate increases have distorted those relationships. Regression analysis may therefore be used to fit existing rates to a rate formula.

3. Conclusions

All the above articles present evidence that it is possible to derive rate calculator formulas, and identify the functional forms that can be expected.

The major conclusions that can be drawn with respect to ocean freight rates are:

- The major factors determining the rates are stowage factor and value per ton in the liner trade. Distance in most cases is not significant.

- The relationships are probably not linear.

The major conclusions that can be drawn from previous research with respect to overland rates are:

- The various modes of transportation have different primary target markets, and therefore adjust their pricing structures to appeal to specific markets.

- Distance along with the value of the cargo are the most important variables in the calculation of rates

- The rate territory has some influence on the rates charged.

---

* E.A. Mattox and E.J. Marien,"Formula Rates; An Idea Whose Time Has Returned." Special Reprint from Traffic World.

(2) Form of the Equations

In order to provide all the component rates for the RSM commodities, rates for six basic types of movements were required:

- Bulk commodities by water (lakewise)
- Bulk commodities by water (overseas)
- Bulk commodities (overland)
- General cargo by water (overseas)
- General cargo (overland by rail)
- General cargo (overland by truck)

The rate structure for each of these movements is significantly different from the others and consequently rate equations for each were produced independently. In addition, within each of these categories it was necessary to develop more than one equation because no combination of variables explained rate levels for the entire category satisfactorily.

The general mathematical form of all rate calculator equations is as follows:

$$\text{Freight Rate} = \sum m_i \times f(V_i) + (\text{Constant})$$

where

m_i is the linear coefficient for term V_i, and $f(V_i)$ is a mathematical transformation or function of the independent variable V_i.

Mathematical transformations used in the equations include natural logarithm, exponential, power, inverse and root functions. This approach permits the use of linear regression analysis while the object equation may involve nonlinear functions.

2. SPECIFICATION OF FREIGHT RATE SAMPLES

The principal consideration which guided the selection of sample freight rates was that only large volume movements would be candidates for rate quotation. This approach was followed because artificially high rate levels are sometimes published in the tariffs for commodities which are moving

only in small volume. Such rates are frequently termed "paper" rates because they exist on paper only and are not used. Furthermore, the level of the freight rate is often the result of interaction between a carrier and one or more shippers or consignees. In such cases a potentially high volume of movement or large lot size may produce downward pressure on rate levels. The rate sample was limited to major movements so that the rate calculator equations would reflect large cargo volumes and would be more valid for allocation of major cargo flows predicted by the Route Split Model.

Five parameters must be specified to determine the freight rate for a specific movement. These are:

- Origin point
- Destination point
- Commodity description
- Mode of carriage (overland movements)
- Shipment size (overland movements)

The methodology for specifying these parameters is described in the following sections.

(1) <u>Identification of Origin, Destination and Commodity</u>

In general, freight rates are published in overland and ocean tariffs for specific commodities (tariff items) moving between specific geographic points, usually cities. The basic level of commodity detail used in the development of the rate calculator equations was the four-digit schedule A or schedule B commodity code. That level of detail is commonly used in published commodity flow data, and is specific enough for analysis of commodity characteristics.

Identification of geographic points for collection of bulk commodity rates was based primarily on the forecasts of the Route Split Model. In those forecasts domestic origins and destinations are reported on a BEA basis. Representative bulk cargo producing cities within BEA's were identified from the following sources:

- <u>Origin-Destination Study of Bulk Commodity Movement, Upper Great Lakes Region</u>, U.S. Army Corps of Engineers, 1972

- *Keystone Coal Industry Manual*, 1975

- *Waterborne Commerce Statistics*, (Part 3) U.S. Army Corps of Engineers, 1975 (lakeside origins)

- Various publications of the U.S. Departments of Interior (for mined products) and Agriculture (for grains)

Representative consuming cities within BEA's were identified from many of the sources above, supplemented by the *1972 Census of Manufacturers*, Area Series (by state). This source was used to identify manufacturing centers which would be the terminations of bulk shipments used as raw material or fuel. It was not necessary to disaggregate bulk commodity families to specific tariff items since most bulk families consist of only one or two principal commodities.

The RSM forecasts identify overseas origins and destinations by foreign trade area. Because overseas bulk shipments move under charter and not liner terms, waterborne rates are not published in liner tariffs. Sample rates were taken from bulk charter quotations reported by overseas country. Consequently specific foreign ports handling bulk commodities were not identified.

The method used to identify geographic points and tariff items for general cargo commodities was considerably more complex. This method was essentially an overlay process which utilized several sources of commodity flow information at different levels of reporting detail. Since most general cargo movements for which rates were required are international, inland points and overseas ports were identified. The technique for specifying inland and overseas origins and destinations for general cargo is described below.

1. Inland Routes

The objective of the process described in this section was to identify cities and four-digit schedule A or B commodities for major movements of general cargo. Data sources used are summarized in Table II-1.

TABLE II-1
Identification of Inland Origins and Destinations for General Cargo

Data Source	Commodity Information				Geographic Information			Comments
	Commod. Family	3-Digit SIC	4-Digit WCC	4-Digit SCH A/B	Nat	State	City	
Route Split Model Forecasts	●					●		—
Census Foreign Trade Statics[1]				●	●			All four digit commodities moving inbound or outbound in significant volume on a national basis
Census of Manufactures[2] (exports)		●					●	Cities (SMSA's) of origin
Major Metropolitan Areas (imports)							●	Cities of destination, assumed to be major metropolitan areas
Waterborne Commerce Statistics[3]			●				●	Commodity mix for Great Lakes ports

[1]Bureau of Census, FT 455/FT 155, Annual 1975, World Area by Commodity Groupings

[2]1972 Area Series, by State

[3]Part 3, Great Lakes, 1974.

The use of this technique is demonstrated in the following sample application. In this example the starting point is the identification of a movement of a commodity family (prime containerizable food products) overseas from the state of Iowa. This initial information is taken from the Route Split Model forecasts. (The commodities and cities included in this example have been limited for the sake of clarity). From Census trade statistics (FT 455) the four-digit commodity content of the family is:

Commodity Description	Sch. B Code	SIC* Code	WCC † Code
Meat by-products	0116	201	2011
Animal fats and oils	4113	201	2014
Hides	2111	201	2015
Dried milk	0222	202	2022
Cheese	0240	202	2021
Wheat flour	0460	204	2041
Breakfast cereals	0481	204	2049

These are the commodities moving outbound from the U.S. as a whole in significant volume. For purposes of identifying origins it is assumed that this distribution of commodities is approximately the same as the actual commodity mix of each state.

As shown above, three different commodity classification schemes are used in commodity trade statistics. A master bridge relating each four digit schedule A or B code to the corresponding

- Route Split Model commodity family

* Standard Industrial Classification

† Waterborne Commerce Code

- SIC code
- WCC code

was developed and computerized for use in the analysis.

The principal Iowa manufacturing centers of food products, according to the Census of Manufacturers, are shown in matrix form below.

	SIC 201	SIC 202	SIC 204
Des Moines	X	X	
Davenport	X		X
Dubuque	X	X	

The above information may be combined to produce the following city and four-digit commodity profile:

	0116	4113	2111	0222	0240	0460	0481
Des Moines	X	X	X	X	X		
Davenport	X	X	X			X	X
Dubuque	X	X	X	X	X		

The process outlined above identifies the inland origin or destination. Potential Great Lakes and ocean port routings were established based essentially on proximity to the inland city. The lake port was chosen subject to a screen of commodities passing through the port based on Part 3 of the Waterborne Commerce Statistics, overseas exports. In the example the appropriate lake port is Chicago, and major exports include the following:

	2011 (0116)	2014 (4113)	2015 (2111)	2022 (0222)	2021 (0240)	2041 (0460)	2049 (0481)	(Sched. B Code) (Wat. Comm. Code)
Port of Chicago		X	X				X	

The corresponding schedule B code is shown in parenthesis above.

Combination of the port profile with the inland origin profile produces the following overland commodity routings:

	0116	4113	2111	0222	0240	0460	0481
To Chicago From Des Moines		X	X				
Davenport		X	X				X
Dubuque		X	X				

For routings to ocean ports it was determined from Waterborne Commerce Statistics that almost all general cargo four-digit commodities identified as major import or export commodities from Census trade statistics move in significant volumes through major ocean ports (Baltimore, Savannah, New Orleans and Long Beach). Consequently the last screen described above was not applied to the selection of inland point-ocean port routings.

2. Overseas Routes

The identification of general cargo routes between U.S. ports and overseas ports was performed in a manner very much like the method described above for inland routings. This method consists of a successive screening or overlay of information from many of the same sources cited previously in order to identify specific ports and commodities for rate quotations. The data sources are summarized in Table II-2.

Table II-2
Identification of Overseas Origins and Destinations of General Cargo

Data Source	Commodity Information				Overseas Origin/Destination				Comments
	Commod. Family	3-Digit SCH A/B	4-Digit SCH A/B	U.S. Port	Trade Area	Country To/ From All U.S. Ports	Country To/Fr. G.L. Ports	Foreign Port	
Route Split Model Forecasts	●								
Census Foreign Trade Statistics[1]			●				●		All four digit commodities moving inbound or outbound in significant volume on a national basis
Census Port-Port Trade Statistics[2]			●	●				●	U.S. ports given foreign ports and commodities
U.S. Great Lakes Port Statistics[3]		●					●		Foreign country and commodity for each G.L. port

1 Bureau of Census, FT 455/FT 155, Annual 1975, World Area by Commodity Groupings

2 Ibid., SA 705/SA 305, Annual 1974.

3 St. Lawrence Seaway Development Corporation, Year to date April thru Dec. 1974.

This method is illustrated below with the same sample application used in the previous section describing inland routes. In that example the Route Split Model forecasts indicated a movement of prime containerizable food products from Iowa to the Mediterranean overseas trade area. In order to identify overseas ports, a matrix showing major overseas ports for each RSM trade area and fourdigit schedule A/B commodities was developed from Census trade statistics (FT 455, FT 155). The food products portion of that matrix for three ports in the Mediterranean trade area is shown below. A complete list of ports by RSM trade area is given in Table II-3.

	0116	0222	0240	0460	0481	2111	4113
Italy (Leghorn*)	X					X	X
Spain (Barcelona*)				X		X	
Egypt (Alexandria*)		X		X	X		

In order to identify U.S. ocean ports to be paired with the foreign ports and commodities above, two successive screens were applied. The U.S. ocean ports considered were Baltimore, Savannah, New Orleans and Long Beach in order to include all four major coastal ranges. Ocean rates involving all ports within each coastal range are generally equalized so that one port per range was adequate. For trade with the United Kingdom and Northern Europe, Montreal was included. For trade with the Caribbean and Central America, Miami was included. The first screen consisted of two matrices (one for each direction) of ocean ports and overseas trade areas which identified those port ranges where ocean rates were equalized. This screen eliminated the possibility of sampling rates for Baltimore and Savannah, for example, if rates from both ports were the same. It was assumed that rates were equalized for all port ranges served by the same conference or rate agreement.

* The Census Statistics above report trade to each foreign country; a major general cargo port within each country was used for that country.

TABLE II-3
Ports by RSM Trade Area

Trade Area	Ports
U.S.A.	Chicago Cleveland Detroit Baltimore Savannah New Orleans Long Beach Miami
Canada	Montreal
Eastern South America	Rio de Janeiro, Brazil La Guaira, Venezuela
Western South America	Guayaquil, Ecuador Valparaiso, Chile Callao, Peru
Caribbean	Kingston, Jamaica Nassau, Bahamas Port-au-Prince, Haiti Santo Domingo, Dominican Republic
Central America	Santo Thomas, Guatemala Puerto Limon, Costa Rico Cristobal, Panama Acajutla, El Salvador
Mexico	Tampico
Northern Europe	Bordeaux, France Rotterdam, The Netherlands Gothenburg, Sweden Copenhagen, Denmark Helsinki, Finland Oslo, Norway
Mediterranean Europe	Leghorn, Italy Barcelona, Spain Piraeus, Greece Marseilles, France Istanbul, Turkey

TABLE II-3 (Continued)

Trade Area	Ports
United Kingdom	London
North Africa	Algiers, Algeria
Developing Africa	Lagos, Nigeria Abidjan, Ivory Coast Mombasa, Kenya
Republic of South Africa	Cape Town
Middle East	Haifa, Israel Jeddah, Saudi Arabia Khorramshar, Iran
Japan	Yokohama
East Asia	Manila, The Phillipines Singapore Hong Kong Kaohsiung, Taiwan Pusan, Korea Djakarta, Indonesia
South Asia	Calcutta, India Karachi, Pakistan
Communist Asia	N.A.
Communist Europe	Gdynia, Poland Leningrad, USSR
Oceania	Sydney, Australia

Savannah, New Orleans and Long Beach in order to include all four major coastal ranges. Ocean rates involving all ports within each coastal range are generally equalized so that one port per range was adequate. For trade with the United Kingdom and Northern Europe, Montreal was included. For trade with the Caribbean and Central America, Miami was included. The first screen consisted of two matrices (one for each direction) of ocean ports and overseas trade areas which identified those port ranges where ocean rates were equalized. This screen eliminated the possibility of sampling rates for Baltimore and Savannah, for example, if rates from both ports were the same. It was assumed that rates were equalized for all port ranges served by the same conference or rate agreement.

The second screen identified the two ocean ports which had the heaviest trade with the foreign port of each commodity shown above. This screen was based on Census port-pair statistics (SA 305, SA 705). The effect of these two screens is illustrated below.

	0116	0222	0240	0460	0481	2111	4113
To Leghorn From							
Baltimore	X					X	X
Savannah*							
New Orleans*	X					X	X
Long Beach	X					X	X
To Barcelona From							
Baltimore				X		X	
Savannah*							
New Orleans*				X		X	
Long Beach				X		X	
To Alexandria From							
Baltimore		X		X	X		
Savannah*							
New Orleans*		X		X	X		
Long Beach		X		X	X		

* Rates equalized; only New Orleans used.

A different technique was used to identify routings from Great Lakes ports. Great Lakes Port Statistics, published by the St. Lawrence Seaway Development Corporation, identifies port-country movements on a three digit schedule A or B basis. The bridge between three- and four-digit commodities was made by assuming that the largest single four-digit commodity exported from the U.S. as a whole (identified above) represented the three digit family moving from the Great Lakes. A portion of this matrix for the Mediterranean trade is shown below.

	0116	0222	0240	0460	0481	2111	4113
To Leghorn From							
Duluth				X			
Chicago						X	
Detroit							X
To Barcelona From							
Duluth							
Chicago						X	
Detroit							
To Alexandria From							
Duluth							
Chicago				X			
Detroit							

3. Mode of Carriage

Alternative transportation modes are available for overland movements of bulk and general cargoes. Since some shipments of almost every bulk commodities move by rail, sample rail rates were collected in order to establish equations for calculating the rail rate for any bulk commodity.

In addition, since some bulks may move overland by other modes, rates for the following modes and commodities were collected:

- Grain: truck and barge
- Petroleum products: pipeline

There are significant movements of coal on the inland waterways. Within the geographic area included in the RSM, the only destination BEA which would be susceptible to a barge movement of coal is the Chicago BEA. However, the RSM does not indicate any coal movements which terminate in the Chicago BEA. There is currently no barge movement of coal from the inland waterways to other lakeside points. Consequently no coal rates by barge were developed.

4. Shipment Size

The level of rail freight rates depends on shipment size. In many cases several different rates are published for the same commodity movement, with lower rates available for higher minimum weights. For all commodities except coal and grains*, single car rail rates were collected, and the rate equations therefore reflect these single car rates.

Most grain and coal shipments move at minimum volumes which are higher than those for single carloads. Consequently rates for multiple car movements of these commodities were collected, and the rates entered in the LPF reflect multiple car movements. The approach followed for coal and grains are described in more detail in the appendices.

5. Rate Collection Procedures

The extraction of rates from published rail, truck and ocean tariffs was performed by firms which specialize in rate quotation services and

* Rate equations were not developed for iron ore, which frequently moves under multiple car or unit train terms.

which maintain extensive in-house tariff libraries. Sample forms used for rate quotations are included in Appendix C. These forms were developed so that information could be keypunched directly from the sheets without manual recoding. Each sheet contains complete information about the rate for one commodity movement, including type of rate, minimum weight, tariff item description, and tariff citation.

Rates for some movements are exempt from ICC or FMC regulation and are not published in public tariffs. These include:

- Lakewise and overseas bulk charters
- Barge and truck grain movements
- Overseas liner rates involving Canadian ports.

In general these rates were developed by contacting the carriers directly, or from compilations of reported charter fixtures. The approach followed and data sources used for each commodity group is described in detail in the appendix.

3. SUMMARY OF STATISTICAL ANALYSIS TECHNIQUES

(1) Input Data

Freight rate was used in all cases as the dependent variable, in combination with one or more of the following as independent variables:

- Stowage factor in measurement tons per long ton
- Value per long ton
- Distance
- Lot or shipment size
- Railroad tariff area
- Class/commodity rate

- Gravity/nongravity commodity

- Origin/destination port range.

The actual values were always used for the first four variables. The remaining four variables were input into the equation as "dummy" variables. Creating "dummy" variables is a technique frequently used in regression analysis to introduce otherwise nonquantifiable nominal-scale variables into the equations. These nominal-scale variables have no values or "scores," by which they can be applied directly as independent variables in the equations. Dummy variables are created by assigning arbitrary values that indicate the "presence" or "absense" of the particular variable. For example, in assigning a dummy variable to indicate whether a bulk commodity was a gravity or non-gravity flow commodity, a value of 0 was used to indicate gravity, and a value of 1 indicated non-gravity.

It was realized that some of the functional relationships might not be linear. Mathematical transformations were applied to the dependent and independent variables (except the dummy variables) in order to test nonlinear in addition to linear functional relationships. The following variable transformations were used:

Dependent Variable	Independent Variables
Inverse $(1/Y)$	Inverse $(1/X)$
Logarithm $(\log(Y))$	Logarithm $(\log_x(X))$
	Exponential (e^x)
	Square root $(\sqrt{X})$
	Second power (X^2)
	Third power (X^3)
	Inverse of square root $\left(\frac{1}{\sqrt{X}}\right)$
	Inverse of 2nd power $(1/X^2)$
	Inverse of 3rd power $(1/X^3)$

(2) Methodology

All statistical analysis was performed with the "Statistical Package For the Social Sciences" (SPSS). This package consists of a widely used set of computerized multiple regression programs.

For the initial step in generating the equations three forms of the dependent variable, i.e., linear, inverse and logarithmic, were tested against each of the linear and the nonlinear transformations of the independent variables. The functional form of each variable that exhibited the best correlation with the dependent variable was then selected. This procedure was performed in a "stepwise" fashion, whereby one new independent variable was added at each step. In this way it was possible to analyze the effect on the statistical indicators of the inclusion of each independent variable.

The statistical indicators evaluated at each step were:

- The coefficient of correlation (r), and the coefficient of determination (r^2). These variables explain the relative variation in the dependent variable that is explained by the independent variable. In other words, the indicators will explain the goodness of fit. These indicators assume values between 0 and 1. A value of 1 indicates a perfect correlation between the dependent and the independent variables, while a value of 0 indicates that there is absolutely no correlation between the dependent and independent variables.

- The F-test. This test is used to check the overall statistical significance of the equation by testing the null hypothesis that the coefficients of all the independent variables are equal to zero and that $r^2=0$. As a rule of thumb, F values of more than 4 are sufficient to reject the null hypothesis with a 95 percent confidence interval, and thus establish the relationship to be statistically significant. For more accuracy critical F values were looked up in a table of the F distribution.

- <u>The t-test</u>. The t-value is used to test the null hypothesis that the coefficient of each particular independent variable is equal to zero, and that particular variable is statistically insignificant in explaining the variation of the dependent variable. The t-values have to be checked in a table of the t-distribution. As a rule of thumb, however, absolute t-values of more than 2 are sufficient to reject the null hypothesis with a 95 percent confidence interval.

Another statistic evaluated in the analysis was the matrix of the correlation coefficients of all the variables in the equations. This statistic also made it possible to check for multicolinearity between the independent variables. Furthermore, it assisted in testing relationships that had coefficients of correlation marginally less than the absolutely "best" relationships selected by the computer.

Multicolinearity is caused by a high degree of correlation between two or more of the independent variables in the equation. The symptoms indicating the possible existence of multicolinearity are a precipitous drop in the F-value of the overall equation and the t-values of two or more previously included variables when one or a set of variables are introduced into the equation. When these symptoms are observed, it is necessary to go back to the matrix of the correlation coefficients to check the correlation between the independent variables. When a high correlation between two or more independent variables was found, the variable causing the multicolineraity was excluded.

After this initial analysis was completed on one sample, the general procedure was as follows:

- Check the r^2, F-values and t-values of the equations, and eliminate automatically equations with r^2 substantially below the other alternative equations

- Check for variables in the remaining equations that were statistically insignificant

- Check for possibilities of multicolinearity, and if identified, exclude variables that cause the condition

- Scan the matrix of correlation coefficients to find another transformation or linear form of independent variables with r^2 marginally less than the "best" relationships included in the initial step.

- Check the table of residuals (i.e., the difference between the actual and predicted values calculated by the equation) for abnormalties. The abnormalities might include:

  - An unreasonable number of "outliers" which are residual values that are more than two standard deviations away from the predicted values or the line of regression

  - Clusters of residuals either above or below the line of regression

  - Changes in the pattern or clusters of scatterplots as the value of the variables increased or decreased.

- Based on the equation, calculate predicted freight rates for values of the independent variables that were outside the range of independent variables in the sample. If these calculated values were found to be unreasonable, the equations were rejected

- Review the form of the equation and compare it to the conventional wisdom of the behavior of freight rates. If an equation exhibited a pattern contrary to the conventional wisdom or previous research while another equation with marginally less goodness of fit did conform to the above criteria, the latter equation was substituted.

The modified "best" relationships plus any new relationships generated after the scan of the correlation matrix were then input to generate another set of equations. The output correlations were then checked as described above. This procedure was repeated until all possibilities of improving the equations were exhausted and the best correlation that satisfied all evaluation criteria was found.

As mentioned above, the equation finally selected was not always the equation that had the highest r^2 and the best F- and t-values. Selection was made based on goodness of fit on validity of the equation at abnormally high or low values of independent variables, and on consistency with the known or observed behavior of freight rates.

4. RESULTS OF THE RATE ANALYSIS

This section summarizes the output of the collection and analysis of freight rates. Two products were produced:

- Rate calculator equations
- File of actual rates for selected movements.

As described at the beginning of this chapter, this rate file contains rates for those movements where the number of rates required to fill ODC cells is so small that development of rate calculator equations was unnecessary.

Complete documentation of the development of all rate equations and related rate data is provided in Appendix G. A summary of the output of the rate analysis for each of the major commodity groups is provided below.

In general the rate equations for overland and lakewise bulk movements calculate rate based on commodity characteristics and city of origin and destination. Overseas rate equations calculate rate as a function of commodity characteristics, U.S. or Canadian port range and foreign trade area.

(1) Grains

The results of the analysis are given below.

Type of Movement	Output of Analysis	Number of Rate Observations
Rail (single car)	10 Equations	141
Rail (multiple car)	Rates for specific movements	-
Truck	1 Equation	(3 independent sources)
Barge	Rates for specific movements (includes truck haul to river terminal if applicable)	-
Lakewise charter	Rates for specific movements	-
Overseas charter	1 Equation	160

Ten different equations for single car rail rates were developed because of the large variation in rail rate based on type of grain and origin and destination point. Single car equations are used only if multiple car rates for the specific origin and destination are not published. As noted above, through barge or truck/barge rates are provided if barge carriage to New Orleans or Chicago is economically feasible. The truck/barge combination includes the transfer cost at the river elevator.

(2) Coal

Results of the coal rate analysis are summarized below.

Type of Movement	Output of Analysis	Number of Rate Observations
Rail (single car)	1 Equation	70
Rail (multiple car)	1 Equation	62
Lakewise charter	Rates for specific movements	-

The single car rail equation is used only when multiple car rates are not applicable.

(3) Iron Ore

Principal component rates for iron ore include:

- Rail transport from mines to ports
- Rail transport from mines to consuming points
- Lakewise movements
- Water movements from the St. Lawrence river to ocean or lake ports

Rates for each of these specific movements were developed and entered directly into the LPF. This involved about 85 ODC's. The principal source of these rates was the Skillings Mining Review.*

(4) Petroleum Products

Results of the analysis are shown below.

Type of Movement	Output of Analysis	Number of Rate Observations
Rail	1 Equation	39
Pipeline	2 Equations	68
Lakewise charter	Rates for specific movements	-
Overseas	Rates for specific movements	-

The pipeline rate equation is used only if there is a direct pipeline between the origin and destination.

* A compilation of overland and waterborne rates and transfer charges is published periodically. The referenced issue was March 12, 1977.

(5) Other Dry Bulk Commodities

The results are summarized below.

Type of Movement	Output of Analysis	Number of Rate Observations
Rail	1 Equation	132
Lakewise charter	1 Equation	13
	Rates for specific movements	-
Overseas charter	1 Equation	44

* All bulks except grain.

Lakewise charter rates for specific limestone movements are given; the equation for lakewise dry bulk charters is used for other commodities.

(6) General Cargo

The results of the general cargo rate analysis are summarized below.

Type of Movement	Type of Cargo	Number of Equations	Number of Rate Observations
Rail	Break Bulk	1	341
	Container	1	131
Truck	Break Bulk	1	196
	Container	1	53
Lakewise	Break Bulk	1	*
Overseas	Break Bulk	26	820**
	Container	26	
	Combination equation	23	

* This equation was based on cost of service relationships.

** A total of 500 outbound and 320 inbound ocean freight rates were analyzed in order to produce these 75 equations.

The analysis of a large ocean freight rate sample indicated significant differences in the rate structure for various U.S. port ranges and foreign trade areas which could not be explained satisfactorily with single equations involving known, quantifiable variables. Consequently a large number of ocean rate equations were developed, as shown above, to represent the widely different rate structures.

In many cases the ocean rates for break bulk and containerized cargo on a given trade were not sufficiently correlated to represent with one equation, so separate equations were produced. In other cases one equation, shown above as a "combination equation," was used for both break bulk and containerized cargo.

* * * *

The next chapter describes the methodology for using the rate calculator model to produce freight rate information compatible with the geographic and commodity framework of the Route Split Model.

III. DEVELOPMENT OF ROUTE SPLIT MODEL FREIGHT RATES

III. DEVELOPMENT OF ROUTE SPLIT MODEL FREIGHT RATES

The rate calculator model described in the previous chapter will produce a rate for movement of a specific commodity over a specific route. The rate requirements of the Route Split Model (RSM),* however, are defined in terms of geographic areas and commodity families. This chapter describes the methodology used to interface the rate calculator model with the geographic and commodity requirements of the RSM.

General cargo flows in the RSM include the following lake-susceptible routings:

- U.S./foreign imports and exports
- Canadian/foreign imports and exports
- U.S./Canadian imports and exports
- Domestic Canadian movements

Interior origins and destinations are defined in terms of 19 hinterland states and nine Canadian areas. Overseas points are identified by nineteen foreign trade areas.

The approach for developing general cargo rates involved the calculation of weighted average rates reflecting the rate distribution resulting from a mix of geographic points in an interior area and the commodity mix within commodity families. The weighted average rate was assigned to the ODC cell, and rate ranges which are measures of the distribution of rates about the average were calculated for each commodity family, direction and type of packaging (container or break bulk).

Origins and destinations of bulk commodity movements are BEA areas (for U.S. points), Canadian areas or overseas foreign trade areas. Because most of the bulk commodity families of the RSM are homogenous, only limited commodity mix weighting was required. Similarly, because most BEA's are small enough that rates to and from one principal city may be used to represent rate levels across the entire BEA, rate weighting due to geographic distribution of origins and destinations was not necessary.

---

* Referred to as "RSM rates" to indicate the total transport cost of an ODC movement.

The development of total transport costs required establishment of potential cargo routings through Great Lakes ports. There are over 175 U.S. harbors on the Great Lakes and tributary waters recognized by the Corps of Engineers. For purposes of rate analysis, however, there are only 24 ports or port groups in the Great Lakes which have distinguishable rate characteristics. These ports are identified below.

- Duluth - Superior
- Presque Isle - Marquette
- Alpena
- Port Inland
- Green Bay
- Milwaukee
- Chicago - Calumet - Burns Harbor
- Muskegon
- Gary
- Saginaw - Bay City
- Detroit
- Toledo
- Cleveland
- Erie
- Buffalo
- Oswego
- Ogdensburg
- Sault Ste. Marie
- Thunder Bay
- Montreal
- Toronto
- Goderich
- Owen Sound
- Little Current.

The hinterland cities for these ports are identified later in this chapter.

The rate information developed in this study for the 24 ports above may be applied to the 43 major Great Lakes harbors considered in other Corps of Engineers' studies by establishing a correspondence between each of the 43 harbors and one of the ports above. The port selected from the list above should be the one which is geographically closest to the port in question and located on the same body of water.

The methodology for development of RSM rates is described in detail below. The approaches for general cargo and bulk commodities are presented separately.

1. GENERAL CARGO

There were five principal considerations in the development of weighted average rates and rate ranges:

- Commodity definition
- Route definition
- Terminal and handling charges
- Weighted through rates
- Rate range

These considerations are discussed below.

(1) Commodity Definition

Commodity profiles were developed from the 1970 Survey of U.S. Foreign Trade. Profiles for both directions and for each RSM commodity family were developed for each of the nineteen hinterland states, and for this hinterland area as a whole. Each profile identifies the eight most significant* four-digit schedule A or B commodities in the commodity family carried by vessel, originating or terminating in a given state. Each state and commodity family profile identifies total tons shipped** for these four-digit commodities and the percentage those tons are of the total tons for all eight commodities (the parameter used in the weighting calculations), as well as total tons for all commodities shipped to or from the state.

The 1970 Foreign Trade Survey is the single most comprehensive data source available which identifies inland origins and destinations of foreign trade. Using this source it was not possible to produce commodity profiles for geographic areas smaller than states. While trade involving sub-state production and market areas are given in this source, there are only 13 production and 7 market areas identified within the nineteen state hinterland.

Rates for each commodity in the profile for the appropriate state and direction were calculated, weighted and summed to produce RSM rates. Only the eight most significant commodities were used to represent the state's commodity mix. If the profile for

* Weight basis
** In the year 1970

the state consisted of fewer than four commodities, however, the profile for the entire hinterland was substituted. There were some commodity families for which the full hinterland profile did not contain at least four commodities. These families were:

- Motor vehicles, parts and equipment (code 32): 2 commodities
- Non-containerizable chemicals (code 34): 2 commodities
- Pig iron (code 35): 1 commodity
- All other non-containerizable (code 36): 1 commodity
- Not classified (code 37): 1 commodity

(2) Route Definition

Definition of Great Lakes and alternative (competitive) routes involved identifying geographic points within domestic (U.S. and Canadian) origin and destination areas, and identifying the Great Lakes or ocean ports corresponding to these points.

There are nineteen states and nine Canadian areas in the RSM domestic hinterland. From one to three cities were selected as O/D points for each state, and one waterside city was used for each Canadian area. Cities were identified based on the production and consumption centers defined during specification of the freight rate samples described previously. One city per state was used for 7 of the 19 hinterland states which are comparatively minor production or market areas and which also are located so far from lake or ocean ports that city to port distances for most cities in the state do not differ significantly.

One potential Great Lakes port was assigned to each O/D city. This assignment was based primarily on proximity of the city to a port currently handling a moderate amount of general cargo. The general cargo hinterland cities of each state and Canadian area, and the Great Lakes port corresponding to each city are identified in Table III-1.

Table III-1
General Cargo Hinterland
Cities

State/Canadian Region	City	Great Lakes Port
New York	Syracuse	Ogdensburg
	Rochester	Buffalo
	Buffalo	Buffalo
Pennsylvania	Pittsburgh	Cleveland
	Philadelphia	Cleveland
	Erie	Cleveland
Ohio	Cleveland	Cleveland
	Columbus	Cleveland
	Cinncinnati	Cleveland
Indiana	Indianapolis	Toledo
	Gary	Gary
	Evansville	Gary
Illinois	Chicago	Chicago
	Peoria	Chicago
	Springfield	Chicago
Michigan	Detroit	Detroit
	Grand Rapids	Detroit
	Lansing	Detroit
Wisconsin	Milwaukee	Milwaukee
	Oshkosh	Green Bay
	Eau Claire	Green Bay
Minnesota	Duluth	Duluth
	Minneapolis-St. Paul	Duluth
	Albert Lea	Duluth
Iowa	Davenport	Chicago
	Cedar Rapids	Chicago
	Des Moines	Chicago
Missouri	St. Louis	Chicago
	Springfield	Chicago
	Kansas City	Chicago

Table III-1 (Continued)

State/Canadian Region	City	Great Lakes Port
North Dakota	Bismark	Duluth
South Dakota	Sioux Falls	Duluth
Nebraska	Grand Island	Chicago
Kansas	Wichita	Chicago
West Virginia	Charleston	Cleveland
	Huntington	Cleveland
	Parkersburg	Cleveland
Kentucky	Louisville	Toledo
	Lexington	Toledo
	Paducah	Chicago
Montana	Billings	Duluth
Wyoming	Cheyenne	Chicago
Colorado	Denver	Chicago
Canada-St. Lawrence	Montreal	Montreal
Canada-L. Ontario	Toronto	Toronto
Canada-L. Erie	Port Colburn	Port Colburn
Canada-L. St. Clair	Windsor	Windsor
Canada-L. Huron	Goderich	Goderich
Canada-St. Mary's R.	Sault Ste. Marie	Sault Ste. Marie
Canada-L. Superior	Thunder Bay	Thunder Bay
Canada-Atlantic	St. John	Montreal
Canada-Pacific	Vancouver	Duluth

For a competitive routing of overseas cargo, rates through ocean ports in as many as six alternative coastal ranges were calculated. A complete through rate (overland haul, terminal charge and ocean freight) was calculated for an ocean port in each coastal range, and the lowest was selected and used in the weighting calculation. For the overland component of each through rate both truck and rail costs were calculated and the lower cost was used. The candidate ocean ports considered for each state and all Canadian regions are summarized in Table III-2.

The four-digit commodity, the inland city and the foreign area involved determine which ocean port has the least cost rate. In this sense the resulting weighted RSM rates for a lake routing and a competitive routing are port-blind since the 24 individual through rates may involve different lake or ocean ports.

(3) Terminal and Handling Charges

A file of terminal charges was developed from published terminal tariffs. Charges at both lake and ocean ports were collected. These charges represent the cost of transferring the cargo between the overland terminal and the pier. Stevedoring costs to transfer cargo between the pier and the vessel are normally for the account of the vessel. A summary of terminal charges is given in Appendix D.

(4) Weighted Through Rates

The procedure described above produced between one and 24 through rates* for each of two routings (lake and competitive) and type of packaging (containerized or break bulk). The weighted rate reflecting the distribution of cities and commodities is given by:

Table III-2
General Cargo Ocean Ports

			Ocean Port		
State/Canadian Region	N. Atl.	S. Atl.*	Gulf	Pacific	Canadian Atl.** †
New York	New York	Savannah	New Orleans	Long Beach	Montreal
Pennsylvania	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Ohio	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Indiana	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Illinois	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Michigan	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Wisconsin	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Minnesota	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Iowa	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Missouri	Baltimore	Savannah	New Orleans	Long Beach	Montreal
North Dakota	Baltimore	Savannah	Houston	Portland	Montreal
South Dakota	Baltimore	Savannah	Houston	Portland	Montreal
Nebraska	Baltimore	Savannah	Houston	Long Beach	Montreal
Kansas	Baltimore	Savannah	Houston	Long Beach	Montreal
West Virginia	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Kentucky	Baltimore	Savannah	New Orleans	Long Beach	Montreal
Montana	Baltimore	Savannah	Houston	Portland	Montreal
Wyoming	Baltimore	Savannah	Houston	Long Beach	Montreal
Colorado	Baltimore	Savannah	Houston	Long Beach	Montreal
Canada-St. Lawrence	Montreal	Savannah	New Orleans	Long Beach	Vancouver
Canada-L. Ontario	Montreal	Savannah	New Orleans	Long Beach	Vancouver
Canada-L. Erie	Montreal	Savannah	New Orleans	Long Beach	Vancouver
Canada-L. St. Clair	Montreal	Savannah	New Orleans	Long Beach	Vancouver
Canada-L. Huron	Montreal	Savannah	New Orleans	Long Beach	Vancouver
Canada-St. Mary's R.	Montreal	Savannah	New Orleans	Long Beach	Vancouver
Canada-L. Superior	Montreal	Savannah	New Orleans	Long Beach	Vancouver
Canada-Atlantic	Montreal	Savannah	New Orleans	Long Beach	Vancouver
Canada-Pacific	Montreal	Savannah	New Orleans	Portland	Vancouver

* Routings through the port of Miami were also evaluated for the Caribbean and South American trades.

** Routings through Montreal were evaluated for Northern Europe and United Kingdom trades.

† Canadian Pacific port for Canadian regions.

$$\bar{R} = \sum_{i=1}^{i_n}\left(\sum_{k=1}^{k_n}\left(R_{ik} \times W_k\right) \times Z_i\right)$$

where i_n = 1 to 3

k_n = 1 to 8

R_{ik} = rate for commodity k and city i

W_k = relative weight for commodity k such that

$$\sum_k W_k = 1.0$$

Z_i = relative weight for city i such that

$$\sum_i Z_i = 1.0 \text{ and all } Z_i \text{ are equal.}$$

---

* One to three cities; one to eight specific commodities.

(5) Rate Range

Allocation of rate-sensitive tonnage to competitive routes is performed in the RSM based on the overlap between ranges of rates, rather than the comparision of individual weighted average rates. In the 1975 version of the LPF the rate range for each commodity family was defined by a scalar variance facton which when multiplied by the mean rate defines the high and low limits of the rate range:

$$R_H = \bar{R} \times (1+F)$$

$$R_L = \bar{R} \times (1-F)$$

Rates were assumed to be uniformly distributed over this range.

For the 1977 LPF scalar variance factors were calculated for each ODC based on the distribution of the several specific rates about the weighted average rate for that ODC. The variance factor for the entire commodity family is the numeric average of the factors for each ODC within the family.

The variance factor for one ODC is given by:

$$F_j = \frac{3}{\overline{R}} \times \left[\sum_{i=1}^{i_n} \sum_{k=1}^{k_n} \left\{ \left[\left(\overline{R} - R_{ijk} \right) \times W_k \times Z_i \right]^2 \right\} \right]^{1/2}$$

where i, k, i_n, k_n, $\overline{R}$, W_k, Z_i are as above

j = route (lake or competitive)

R_{ijk} = rate for route j, city i and commodity k.

As shown in the expression, the rate range will be equivalent to three weighted standard deviations of the rate distribution.

The variance factor for an entire commodity family is the numeric average of all F_j in that family. These factors are summarized in Appendix E.

2. BULK CARGO

As described above, weighted rates and variance factors were not calculated for bulk commodities because of the homogeneity of interior origins and destinations (BEA's) and commodity families. The limited heterogeneity of a few families was represented by weighted average stowage factor and value per ton. This was true for the following commodity families:

- Other grain (5)
- Other farm produce (6)
- Fuels (9)
- Other petroleum products (10)
- Other building materials (14)
- Other mineral products (15)
- Other ores (17)
- All other bulk (22)

The rates entered in the LPF, therefore, correspond to point-to-point movements of specific commodities. Two

other considerations in the development of bulk rates which differ somewhat from the general cargo approach:

- Route definition
- Terminal and handling charges

are discussed below.

(1) Route Definition

Great Lakes and competitive routes for overseas movements were defined in the same way that general cargo routes were defined. This approach, as described above, involved a lake routing which connected a representative city in the BEA with the nearest principal lake port, and a routing through the one of six candidate ocean ports which produced the lowest through rate.

Development of a route to connect domestic BEA's or Canadian areas involved the following steps. First, each BEA was associated with the nearest principal lake port. Some BEA's, however, are approximately equidistant from ports on two different lakes. For example, BEA 60 (Indianapolis) is about the same distance from Gary (Lake Michigan) and Toledo (Lake Erie). In these cases both were considered to be candidate ports.

A domestic movement between two inland BEA's might therefore involve up to four potential routings, if each BEA were associated with two lake ports. The rate entered in the LPF corresponded to the route with the lowest through rate; i.e., the sum of land haul, water haul, terminal charge and Seaway tolls if applicable. This route thus depended on the commodity and the ultimate destination.

(2) Terminal and Transfer Charges

Vessel charter rates normally specify free in-and-out terms, which means transfer of cargo in and out of the vessel is for the account of the cargo. A file of terminal charges by port and commodity which reflect these costs were developed. Bulk terminal charges are summarized in Appendix D.

Terminal charges are usually negotiated by the terminal operator and the shipper and are not publicly available. Even rates in published terminal tariffs may be negotiated. The handling charge data were developed by contacting major terminal operators in principal lake and ocean ports. These operators provided rates which they indicated were representative of current negotiated rates.

The method for applying transfer costs to overseas bulk movements is the same as the method used for general cargo which was described above. The method for applying transfer costs for domestic routes is described below.

In general a domestic route through the Great Lakes would involve the following transfer costs, as shown in Figure III-1:

- Loading at origin to an overland mode* (shown as A1 in the figure)
- Transfer from overland mode to lake vessel (A3)
- Transfer from vessel to overland mode, if the destination is inland (A4)
- Unloading at destination (A2).

The competitive route is a direct overland haul from origin to destination and involves only a loading cost (B1) and an unloading cost (B2).

Handling charges were added to the total transport cost based on the assumption that the difference between loading costs A1 and B1, and unloading costs A2 and B2 is negligible compared to the total transport costs and does not affect the relative cost of competing routes. Therefore the only handling charges which were included in the transport costs entered in the LPF were A3 and A4.**

* The drayage from origin to vessel rail, even for lakeside BEA's, is long enough that application of transfer cost A3 is valid.

** Handling charge A4 is required only if the destination BEA is inland.

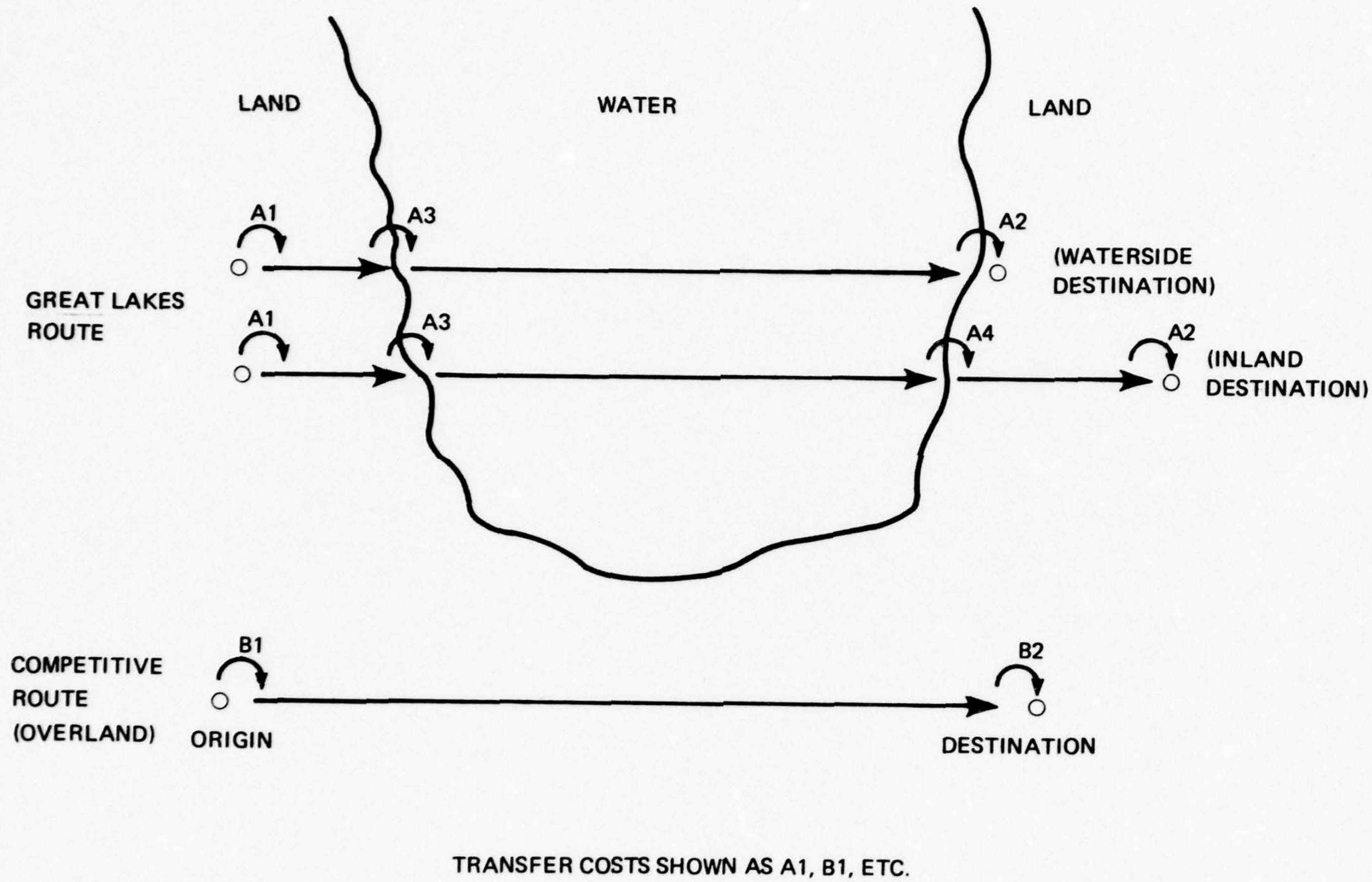


FIGURE III-1
Application of Transfer Costs
(Domestic Movements)

*   *   *   *

The next chapter describes validation tests which were applied to the rate calculator model, and presents observations concerning the application of the results of the study to rate-based traffic analysis.

IV. EVALUATION AND UTILITY OF THE LOGISTICS PRICE FILE

IV. EVALUATION AND UTILITY OF THE LOGISTICS PRICE FILE

This chapter is intended to provide a perspective for application of the results of the study to rate-based traffic analysis. The first section of the chapter contains a summary of observations concerning the nature of the approach for developing the Logistics Price File and potential sources of error. The second section describes analytic tests which were applied to the rate calculator model to determine the sensitivity of cargo allocations to potential inaccuracies in calculated freight rates. These tests demonstrate that the rate calculator model is a valid representation of the Great Lakes rate structure.

1. OBSERVATIONS CONCERNING STUDY APPROACH

The objective of the study was to provide a measure of the relative cost advantage or disadvantage of a Great Lakes cargo route compared to a competitive routing. The two-phased approach to meeting this objective:

- Sampling freight rates to produce a rate calculator model
- Using the rate calculator model to develop simple and weighted freight rates covering an extensive universe of commodity movements

has several inherent sources of error which affected the validity of the LPF. Key elements of the study approach are identified below, and the implication of those aspects of the approach are discussed.

(1) Freight Rate Sample Specifications

As described earlier in the report, commodity, origin and destination for the freight rate samples were specified with great care. However, these specifications may not correspond perfectly to the most frequently used freight rates, because of imprecision

in identifying origins and destinations and because of the multiplicity of specific tariff items within a four-digit commodity group.

(2) Collection of Sample Rates

Observed rates were provided by firms specializing in rate quotation and tariff searches. The validity of these rates depends on the thoroughness of research to identify the lowest applicable rate for a given movement. In addition, subjective judgment is required to specify routings involving transshipment points. These postulated routings may differ from actual routings.

(3) Goodness-of-Fit of Rate Calculator Equations

One of the most important considerations of accuracy involves the goodness of fit of the rate equations to the observed freight rates. The standard statistical parameter reflecting goodness of fit is the coefficient to determination (r^2 parameter). Values for r^2 for all rate equations are given in Appendix G. For most of these equations, r^2 values are well within a statistically acceptable range.

It is reasonable to assume that errors induced by fitting curves to the rate samples would not induce a rate bias for or against a Great Lakes routing. In this sense the impact of goodness of fit is mitigated over the complete universe of more than 16,000 rates in the LPF. The validity of the rate calculator equations is discussed in more detain in the next section.

(4) Weighting Methodology for General Cargo Rates

The basis for the weighting methodology was commodity profiles by state, developed from the 1970 Survey of Foreign Trade. The validity of this weighting technique is therefore dependent on the validity of the data in the 1970 Survey.

2. VALIDATION OF ANALYSIS TECHNIQUES

Several potential sources of error inherent in the study approach were highlighted in the previous section. Most of these potential errors are associated with the

nature of specifying and collecting freight rates. The rate collection was performed with maximum care to minimize these errors, and consequently it is likely that the collected rates present a representative profile of the cost competitiveness of the Great Lakes system.

The development of rate calculator equations, however, is the single element of the approach which must be evaluated for potential distortion of the rate attributes of specific commodity routings. This section describes a series of validation tests which were applied to the rate calculator model to determine the:

- Goodness of fit of the rate calculator equations
- Implication of potential calculator equation errors on cargo allocation.

These validation procedures are described below.

(1) <u>Goodness of Fit of Rate Calculator Equations</u>

To determine goodness of fit, predicted rates were compared to actual rates. The comparison was performed for the most important equations in the rate predictor model.

The approach involved selecting rates at random from the statistical rate sample used to develop a particular equation. The size of this "sub-sample" was in all cases about 10 percent of the full sample. For each rate in the sub-sample, a rate was then calculated and compared to the actual rate.

The error associated with each observation was the difference between calculated and actual; the sign of the difference was disregarded. Average percentage error was defined to be the average error divided by the average actual rate.

The rate calculator model includes 75 equations for ocean liner rates. Each of these equations was not tested independently. Rather, a 10 percent sub-sample was taken of the complete liner rate sample, and the equation corresponding to each of these rates was used to calculate a comparative rate. This approach involved using all but 12 of the 75 ocean rate equations.

In the process of developing estimates of average error it was observed that for a given rate sub-sample, while most calculated rates were reasonably close to actual rates, in a few instances the relative error was quite large. Average percentage error (and the coefficient of determination r^2) will be much higher because of these exceptional "outliers" than would occur otherwise.

An "adjusted" average percentage error was calculated for each sub-sample by eliminating the worst outliers from the sub-sample. The number of excluded outliers was always less than 10 percent of the sub-sample size. The adjusted error is therefore a measure of the equation's goodness of fit with respect to most of the observed rates.

The results of the goodness of fit analysis are summarized in Table IV-1. The following conclusions may be drawn from the table:

- The adjusted average error for ocean liner rates varies between 15 and 25 percent
- The adjusted average error for overland rates varies between 3 and 20 percent
- Elimination of outliers reduced the average error by as much as 6 percent.

The error terms were studied to determine whether the equations consistently over or underestimated observed rate levels. It was found that the equations did not introduce a rate bias to either the advantage or disadvantage of the Great Lakes system.

This analysis indicates that in general the rate calculator model may be expected to predict a rate for a specific movement within plus or minus 25 percent of the actual rate. While this inaccuracy is significant for individual freight rates, the consequences with respect to cargo allocation is mitigated due to the nature of the cargo allocation technique of the Route Split Model. This is discussed in the next section.

TABLE IV-1

Goodness-of-Fit of Rate Calculator Equations

Commodity and Mode	Number of Observations	Error Sample Size	Average Error	Average Adjusted Error*
Ocean				
General Cargo, Export, Break Bulk	500	44	20%	15%
Container			21%	16%
General Cargo, Import, Break Bulk	320	31	18%	17%
Container			25%	25%
Rail				
General Cargo, Break Bulk	431	34	22%	20%
Container	131	15	13%	10%
Coal	70	10	7%	5%
Other Dry Bulk	90	20	9%	8%
Truck				
General Cargo, Break Bulk	106	20	24%	18%
Container	52	10	4%	3%

* Calculated by eliminating observations with the largest errors. The number of excluded "outliers" was always less than 10% of the error sample size.

(2) <u>Validity of Rate Calculator Model for Cargo Allocation</u>

The allocation of rate-sensitive tonnage of a Great Lakes or competitive route is performed by the Route Split Model using a rate range concept. This method assumes that each rate in the Logistics Price File is actually a mean rate reflecting a distribution of rates. The distribution is due to the variation in specific commodity, origin and destination with the commodity families and geographic areas which define each ODC. The rate range established about each mean rate reflects this distribution.

Cargo is allocated to competitive routes based on the difference between mean rates and the degree of overlap of the rate ranges. The allocation method is described by a hypothetical situation illustrated in Figure IV-1.

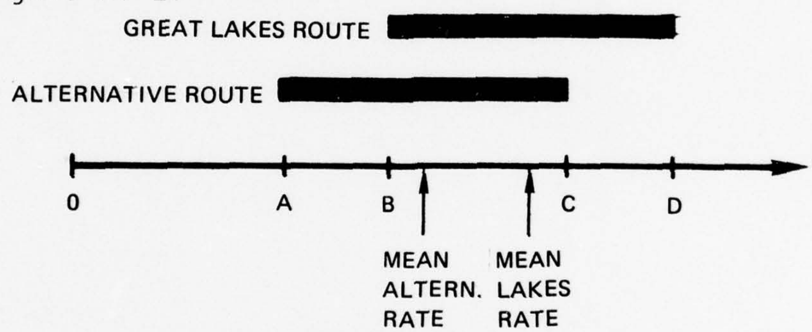


FIGURE IV-1
Route Split Model Cargo Allocation Method

In this example, the Great Lakes share percentage is given by:

$$P = \frac{1/2\ (C-B)}{C-A}$$

As described above, the estimation of equation goodness of fit was based on a comparison of actual rates and calculated rates. In a similar way, a determination of the relationship between rate calculator inaccuracy and cargo allocation inaccuracy was made by applying the cargo allocation technique described above to both actual and calcualted rates. Ocean liner rates were used for this analysis because as shown in Table IV-1 previously, the average error for liner rates was in general greater than the average error for any other

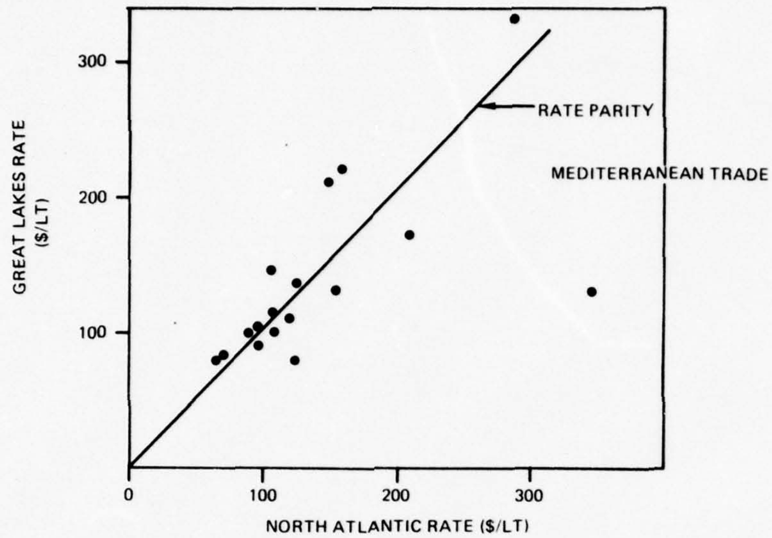
type of movement, and because the ocean component of a complete overseas rate is ordinarily much greater than the overland component. Two trades, Northern Europe and the Mediterranean, were analyzed independently. These are two of the heaviest trades involving the Great Lakes.

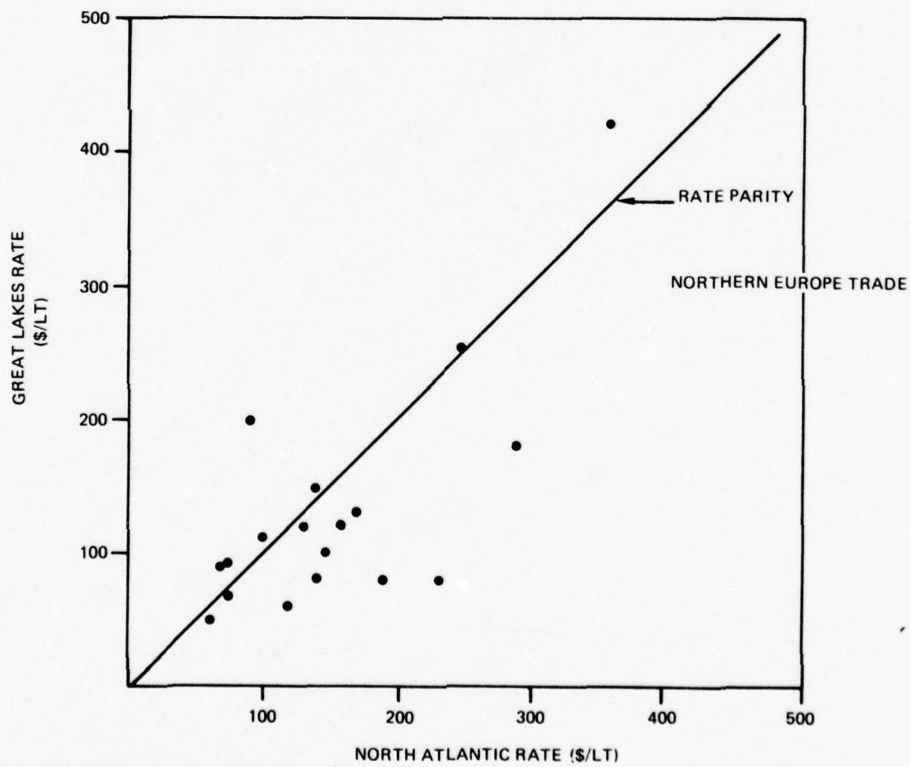
Cargo allocations were performed as follows:

- The sample of actual liner rates was screened to retain only the commodities for which a rate involving both a Great Lakes port and a U.S. North Atlantic port had been collected
- For each of these commodities a Great Lakes and North Atlantic rate was calculated
- A uniform hypothetical tonnage for each commodity was split between routes by applying a typical rate range (± 20 percent) to each actual rate
- An identical tonnage was allocated based on the average calculated rates (the technique used in the Route Split Model).

The cargo split (Great Lakes and North Atlantic) using actual rates and calculated rates was then compared. The method and results of this analysis are documented below. Figure IV-2 shows the distribution of actual rates for both overseas trades. Tables IV-2 and IV-3 summarize the results for the Northern Europe and Mediterranean trades respectively.

As shown in the tables, the rate calculator equations produced significant inaccuracies (16 to 37 percent) when absolute errors are compared to the actual rates. However, the corresponding "error" in tonnage allocation is only 2 to 4 percent. The principal explanation for this phenomenon is that while the equations will not produce reliable absolute rates, relative rate differences are maintained. Consequently, the rate levels reflected by the rate equations in 1977 LPF on the whole are highly representative of cost advantages or disadvantages of the Great Lakes system.





INBOUND AND OUTBOUND RATES
MODE OF TRANSPORT: CONTAINER

FIGURE IV-2
Freight Rates Analyzed For Validation Tests

TABLE IV-2
Validation of Tonnage Allocation
(Northern Europe Trade)

	Great Lakes	North Atlantic
Average Freight Rate:		
. Actual	$132	$156
. Calculated	$130	$150
Average Error Per Calculated Rate*	$ 49	$ 41
Average Percentage Error of Calculated Rates	37%	26%
Tonnage Allocation Using:		
. Actual Rates	61%	39%
. Calculated Rates	65%	35%

Sample includes both inbound and outbound rates
Mode of Transport: Container
All Freight Rates Per Long Ton

* Independent of sign of the error.

TABLE IV-3
Validation of Tonnage Allocation
(Mediterranean Trade)

	Great Lakes	North Atlantic
Average Freight Rate:		
. Actual	$136	$141
. Calculated	$138	$138
Average Error Per Calculated Rate*	$ 27	$ 23
Average Percentage Error of Calculated Rates	20%	16%
Tonnage Allocation Using:		
. Actual Rates	48%	52%
. Calculated Rates	50%	50%

Sample includes both inbound and outbound rates
Mode of Transport: Container
All Freight Rates Per Long Ton

* Independent of sign of the error.

V. MAINTENANCE OF THE LOGISTICS PRICE FILE

V. MAINTENANCE OF THE LOGISTICS PRICE FILE

The previous chapters have documented the development of a Logistics Price File which is representative of freight rate levels in effect during the Spring of 1977. It is well known that freight rates are dynamic and are adjusted frequently. This chapter presents a methodology for maintenance of the LPF to ensure that the file reflects current rate levels.

There are two general types of freight rate increases or decreases:

- Across-the-board rate changes which may reflect, among other factors, a change in the carrier's overall cost of providing transportation services
- Selected rate changes which reflect changes in market factors involving specific commodity movements or trade routes.

Across-the-board rate changes which reflect cost changes are usually increases rather than decreases. In collecting sample freight rates several cases were observed where amendments had been published to increase all rates in the tariff by a flat percentage. It is a common occurence for a current rail freight rate to be calculated by applying several percentage increases to a comparatively old tariff rate. This experience indicates a general upward trend in freight rates where increases are applied as uniform percentages.

In theory the implementation of a new technology to freight transportation might result in decreased cost to the carrier which would be passed on to the shipper in the form of across-the-board rate reductions. This type of situation occurred during the introduction of containerization on the North Atlantic-Europe trade. Participation of several new container carriers in that trade produced an overtonnage situation with intense competition for the same amount of cargo. The cost savings of containerization allowed the container carriers to reduce rates significantly. Many break-bulk carriers discontinued their service rather than

convert to containerization, thus bringing supply back in line with demand. When this situation stabilized, overall rate levels had been reduced.

The second general type of rate changes are due to changes in the transportation environment of Great Lakes susceptible cargo. This would include changes to the pattern of commodity flows in the Great Lakes, and transportation service offered by carriers competing for this cargo. Corresponding rate adjustments reflect value-of-service considerations which are present in the rate setting process. Market factors which may be related to rate changes include:

- Level of competition for specific commodities from other modes or carriers
- Relative desirability of certain commodities
- Relocation of commodity production or market centers within the U.S.
- Long term changes in the trade partners and commodities of international commerce

The methodology for updating the LPF consists of two elements. The first element involves adjusting the coefficients of the rate calculator equations to reflect across-the-board rate increases. The second element involves a more selective modification of the rate calculator model to account for any significant change in prevailing freight rates due to a change in market factors. This modification would require redevelopment of certain rate calculator equations. These two elements are described in more detail below.

1. RECALIBRATION OF RATE CALCULATOR EQUATIONS

The equations may be recalibrated by collecting a new freight rate sample of a much smaller size than the sample used to develop the rate calculator model. These new rate observations may be used to adjust the rate equation coefficients and to modify the small file of component rates which are entered directly into the LPF.

The recommended minimum number of rates which should be collected for each equation or group of equations is shown in Table V-1. As indicated in the table, in some cases

several equations were developed for a general type of movement (such as general cargo ocean rates) to represent widely different rate structures (by port range and overseas trade area). In these cases it is necessary to collect new sample rates for the general type of movement and not for each rate equation.

Specifications for the new rate samples may be taken from the raw data of the 1977 rate sample. These data identify origin, destination, commodity description, mode and shipment size. The selection of the required number of rates should be random.

A correction factor for each equation in the group may be calculated by averaging the relative increase of each rate in the new sample. This correction factor K based on n new sample rates is therefore:

$$K=\left(\sum_{i=1}^{n} \frac{RN_i}{RO_i}\right)/n$$

where RO_i is the 1977 rate (from the 1977 raw rate data), and the RN_i is the new rate for the same ODC. The coefficients of new equation for this group are calculated by multiplying all the cofficients of the 1977 equation by this factor K. For those movements for which the rate calculator model contains actual rates and not equations, all the rates should be adjusted using the correction factor.

2. SELECTIVE DEVELOPMENT OF NEW RATE CALCULATOR EQUATIONS

New rate calculator equations should be developed for those movements affected by a change in market factors which has produced a significantly different rate structure. In these cases a rate sample should be collected which is at least as large as the sample used to produce the 1977 equation for the movement in question. Statistical regression analysis should then be used to develop a new rate equation.

The key element in this process is determining which types of movements have undergone a major rate structure change. This can be accomplished by a careful monitoring of transportation developments in the Great Lakes system and in competiting modes and routes. The monitoring should focus on the major commodities of the Great Lakes hinterland which

Table V-1
Recalibration of Rate Calculator Equations
1977 Rate Model

Commodity	Type of Movement	No. of Equations	No. of Rate Observations	Updated Rate Sample (No. of Observations)
Grain	Rail	10*	141*	30
	Truck	1	**	15
	Barge	#	#	15
	Lakewise	#	#	10
	Ocean	1	160	20
Coal	Rail	2	132	40
	Lakewise	#	#	10
Iron Ore	Rail, Lakewise and Ocean	†	†	†
Other Dry Bulk	Rail	1	132	25
	Lakewise	1	13	5
	Ocean	1	44	15
Liquid Bulk	Rail	1	39	15
	Pipeline	2	68	15
	Lakewise	#	#	10
	Ocean	#	#	5
General Cargo	Rail (BB)	1	341	40
	(Ctr)	1	131	20
	Truck (BB)	1	196	30
	(Ctr)	1	53	15
	Lakewise	2	‡	5
	Ocean (export)	39	500	50
	(import)	36	320	50

* Supplemented by rates for specific movements

** Three independent sources were used to develop the equation

\# Consists of rates for specific movements

† There are only a limited number of component rates, all of which may be updated directly

‡ Based on cost-of-service relationships

are likely to be affected by new developments. These commodities include general cargo, grains, coal and iron ore.

Several potential developments which would indicate probable changes in freight rate levels include the following:

- Entry of a new carrier in the market. For example, the initiation of Great Lakes European Lines' container service in the lakes has had an important impact on general cargo freight rates.

- Participation of a strong independent carriers or carriers in a conference trade. The competition from independents usually has an impact on conference tariffs

- Dissolution or establishment of conferences or rate agreements

- Publishing of new unit train or multiple car tariffs. In the past several years a wave of unit train grain elevator construction has moved gradually westward. If this trend continues unit train grain service will be offered from western states which do not have such a service now.

- Emergence of new major production or market centers. An example is a continued increase in the movement of western coal to midwest and eartern markets. Frequently an increase in potential tonnage may have a depressing effect on rates if there is competition for the cargo.

There is no way to determine the extent to which developments such as those above may influence the level of rates. Consequently the recommended procedure is to collect a new rate sample and to compare with the raw 1977 rate data. Sample sizes on the order of those used to develop the 1977 rate calculator equations, as shown in Table V-1, should be used. If discrepancies appear significant, new equations should be developed.

APPENDIX A

DEFINITION OF COMMODITY GROUPS

APPENDIX A

Definition of Commodity Groups

Bulk

1. Corn
2. Wheat
3. Soybeans
4. Barley and Rye
5. Other Cash Grain
6. Other Farm Produce
7. Coal
8. Crude Petroleum
9. Fuels
10. Other Petroleum Products
11. Limestone
12. Building Cement
13. Salt
14. Other Building Materials
15. Other Mined Products
16. Iron Ore and Concentrates
17. Other Ores
18. Iron and Steel Scrap
19. Standard Newsprint Paper
20. Coke, Petroleum Coke
21. Pulp
22. All Other Bulk

General Cargo

Prime Container

23. Food and Kindred Products
24. Chemicals
25. Fabricated Metals Products
26. All Other

Potential Container

27. Food and Kindred Products
28. Chemicals
29. Iron and Steel Products
30. Machinery, except Electrical
31. Electrical Machinery and Equipment

Definition of Commodity Groups (Continued)

32. Motor Vehicles, Parts, Equipment
33. All Other

Not Suitable for Container

34. Chemicals
35. Pig Iron
36. All Other
37. Not Classified According to Kind

APPENDIX B

REGION CODES

APPENDIX B

REGION CODES

Great Lakes Border Regions

Internal Code	Definition		
1	BEA-7	St. Lawrence	Syracuse, N.Y.
2	BEA-7	Lake Ontario	Syracuse, N.Y.
3	BEA-8	Lake Ontario	Rochester, N.Y.
4	BEA-9	Lake Ontario	Buffalo, N.Y.
5	BEA-9	Lake Erie	Buffalo, N.Y.
6	BEA-10	Lake Erie	Erie, PA
7	BEA-68	Lake Erie	Cleveland, Ohio
8	BEA-70	Lake Erie	Toledo, Ohio
9	BEA-71	Detroit River & Lake St. Clair	Detroit, Mich.
10	BEA-72	Lake Huron	Saginaw, Mich.
11	BEA-72	Lake Superior	Saginaw, Mich.
12	BEA-72	St. Mary's River	Saginaw, Mich.
13	BEA-73	Lake Michigan	Grand Rapids, Mich.
14	BEA-76	Lake Michigan	South Bend, Ind.
15	BEA-77	Lake Michigan	Chicago, Ill.
16	BEA-84	Lake Michigan	Milwaukee, Wis
17	BEA-85	Lake Michigan	Appleton-Oshkosh, Wis.
18	BEA-85	Lake Superior	Appleton-Oshkosh, Wis.
19	BEA-87	Lake Superior	Duluth-Superior, Min., Wis.
20	Small ports on GL/SLS		

Great Lakes Hinterland

Internal Code	Definition	
21	BEA-6	Albany-Schenectady-Troy, N.Y.
22	BEA-11	Williamsport, Pa.
23	BEA-12	Binghamton, N.Y.- Pa.
24	BEA-16	Harrisburg, Pa.
25	BEA-19	Staunton, Va.
26	BEA-49	Nashville, Tenn.
27	BEA-50	Knoxville, Tenn.
28	BEA-51	Bristol, Va.-Tenn.
29	BEA-52	Huntington-Ashland, W. Va.-Ky.-Ohio

Great Lakes Hinterland
(Continued)

Internal Code		Definition
30	BEA-53	Lexington, Ky.
31	BEA-54	Louisville, Ky.- Ind.
32	BEA-55	Evansville, Ind.-Ky.
33	BEA-56	Terre Haute, Ind.
34	BEA-57	Springfield, Ill
35	BEA-58	Champaign-Urbana, Ill.
36	BEA-59	Lafayette-West Lafayette, Ind.
37	BEA-60	Indianapolis, Ind.
38	BEA-61	Anderson, Ind.
39	BEA-62	Cincinnati, Ohio-Ky,-Ind.
40	BEA-63	Dayton, Ohio
41	BEA-64	Columbus, Ohio
42	BEA-65	Clarksburg, W. Va.
43	BEA-66	Pittsburgh, Pa.
44	BEA-67	Youngstown-Warren, Ohio
45	BEA-69	Lima, Ohio
46	BEA-74	Lansing, Mich.
47	BEA-75	Fort Wayne, Ind.
48	BEA-78	Peoria, Ill.
49	BEA-79	Davenport-Rock Island-Moline, Iowa-Ill.
50	BEA-80	Cedar Rapids, Iowa
51	BEA-81	Dubuque, Iowa
52	BEA-82	Rockford, Ill.
53	BEA-83	Madison, Wis.
54	BEA-86	Wausau, Wis.
55	BEA-88	Eau Claire, Wis.
56	BEA-89	La Crosse, Wis.
57	BEA-90	Rochester, Minn.
58	BEA-91	Minneapolis-St. Paul, Wis.
59	BEA-92	Grand Forks, N.D.
60	BEA-93	Minot, N.D.
61	BEA-94	Great Falls, Mont.
62	BEA-95	Billings, Mont.
63	BEA-96	Bismarck, N.D.
64	BEA-97	Fargo-Moorhead, N.D.-Minn.
65	BEA-98	Aberdeen, S.D.
66	BEA-99	Sioux Falls, S.D.

Great Lakes Hinterland
(Continued)

Internal Code		Definition
67	BEA-100	Rapid City, S.D.
68	BEA-101	Scottsbluff, Nebr.
69	BEA-102	Grand Island, Nebr.
70	BEA-103	Sioux City, Iowa-Nebr.
71	BEA-104	Fort Dodge, Iowa
72	BEA-105	Waterloo, Iowa
73	BEA-106	Des Moines, Iowa
74	BEA-107	Omaha, Nebr.-Iowa
75	BEA-108	Lincoln, Nebr.
76	BEA-109	Salina, Kansas
77	BEA-110	Wichita, Kansas
78	BEA-111	Kansas City, Mo.-Kansas
79	BEA-112	Columbia, Mo.
80	BEA-113	Quincy, Ill.
81	BEA-114	St. Louis, Mo.-Ill.
82	BEA-115	Paducah, Ky.
83	BEA-116	Springfield, Mo.
84	BEA-147	Colorado Springs, Colorado
85	BEA-148	Denver, Colorado
86	BEA-149	Grand Junction, Colorado
87	BEA-150	Cheyenne, Wyoming
88	BEA-151	Salt Lake City, Utah
89	BEA-152	Idaho Falls, Idaho
90	BEA-153	Butte, Mont.

Customs Districts (General Cargo Only)

Internal Code	Definition
91	New York
92	Pennsylvania
93	Ohio
94	Indiana
95	Illinois
96	Michigan
97	Wisconsin
98	Minnesota
99	Iowa
100	Missouri
101	North Dakota

Customs Districts (General Cargo Only) (Continued)

Internal Code	Definition
102	South Dakota
103	Nebraska
104	Kansas
105	West Virginia
106	Kentucky
107	Montana
108	Wyoming
109	Colorado

Canadian Regions

Internal Code	Definition
110	St. Lawrence
111	Lake Ontario
112	Lake Erie
113	Lake St. Clair
114	Lake Huron
115	St. Mary's River
116	Lake Superior
117	Other Great Lakes Ports
118	Canadian Atlantic
119	Canadian Pacific
120	Other Canadian Ports

Overseas Regions

Internal Code	Definition
121	Eastern South America
122	Western South America
123	Caribbean
124	Central America
125	Mexico

Overseas Regions
(Continued)

Internal Code	Definition
126	Northern Europe
127	Mediterranean Europe
128	United Kingdom
129	North Africa
130	Developing Africa
131	Republic of South Africa
132	Middle East
133	Japan
134	East Asia
135	South Asia
136	Communist Asia
137	Communist Europe
138	Oceania

Other BEAs

Internal Code	Definition	
139	BEA- 1	Bangor, Maine
140	BEA- 2	Portland-South Portland, Maine
141	BEA- 3	Burlington, Vt.
142	BEA- 4	Boston, Mass.
143	BEA- 5	Hartford, Conn.
144	BEA-13	Wilkes-Barre-Hazleton, Pa.
145	BEA-14	New York, N.Y.
146	BEA-15	Philadelphia, Pa.-N.J.
147	BEA-17	Baltimore, Md.
148	BEA-18	Washington, D.C.-Md.-Va.
149	BEA-20	Roanoke, Va.
150	BEA-21	Richmond, Va.
151	BEA-22	Norfolk-Portsmouth, Va.
152	BEA-23	Raleigh, N.C.
153	BEA-24	Wilmington, N.C.
154	BEA-25	Greensboro-Winston Salem-High Point, N.C.
155	BEA-26	Charlotte, N.C.
156	BEA-27	Ashville, N.C.
157	BEA-28	Greenville, S.C.

Other BEAs
(Continued)

Internal Code	Definition	
158	BEA- 29	Columbia, S.C.
159	BEA- 30	Florence, S.C.
160	BEA- 31	Charleston, S.C.
161	BEA- 32	Augusta, Ga.
162	BEA- 33	Savannah, Ga.
163	BEA- 34	Jacksonville, Fla.
164	BEA- 35	Orlando, Fla.
165	BEA- 36	Miami, Fla
166	BEA- 37	Tampa-St. Petersburg, Fla.
167	BEA- 38	Tallahassee, Fla.
168	BEA- 39	Pensacola, Fla.
169	BEA- 40	Montgomery, Ala.
170	BEA- 41	Alabany, Ga.
171	BEA- 42	Macon, Ga.
172	BEA- 43	Columbus, Ga.-Ala.
173	BEA- 44	Atlanta, Ga.
174	BEA- 45	Birmingham, Ala.
175	BEA- 46	Memphis, Tenn.-Ark.
176	BEA- 47	Huntsville, Ala.
177	BEA- 48	Chattanooga, Tenn.-Ga.
178	BEA-117	Little Rock-North Little Rock, Ark.
179	BEA-118	Fort Smith, Ark.-Okla.
180	BEA-119	Tulsa, Oklahoma
182	BEA-120	Oklahoma City, Okla.
183	BEA-121	Wichita Falls, Texas
184	BEA-122	Amarillo, Texas
185	BEA-123	Lubbock, Texas
186	BEA-124	Odessa, Texas
187	BEA-125	Abilene, Texas
188	BEA-126	San Angelo, Texas
189	BEA-127	Dallas, Texas
190	BEA-128	Killeen-Temple, Texas
191	BEA-129	Austin, Texas
192	BEA-130	Tyler, Texas
193	BEA-131	Texarkana, Texas-Ark.
194	BEA-132	Shreveport, La.
195	BEA-133	Monroe, La.
196	BEA-134	Greenville, Miss.
197	BEA-135	Jackson, Miss.
198	BEA-136	Meridian, Miss.
199	BEA-137	Mobile, Ala.

Other BEAs
(Continued)

Internal Code	Definition	
200	BEA-139	Lake Charles, La.
201	BEA-140	Beaumont-Port Arthur-Orange, Texas
202	BEA-141	Houston, Texas
203	BEA-142	San Antonio, Texas
204	BEA-143	Corpus Christi, Texas
205	BEA-144	McAllen-Pharr-Edinburg, Texas
206	BEA-145	El Paso, Texas
207	BEA-146	Albuquerque, N.M.
208	BEA-154	Spokane, Wash.
209	BEA-155	Seattle-Everett, Wash.
210	BEA-156	Yakima, Wash.
211	BEA-157	Portland, Oregon-Wash.
212	BEA-158	Eugene, Oregon
213	BEA-159	Boise City, Idaho
214	BEA-160	Reno, Nev.
215	BEA-161	Las Vegas, Nev.
216	BEA-162	Phoenix, Ariz.
217	BEA-163	Tucson, Ariz.
218	BEA-164	San Diego, California
219	BEA-165	Los Angeles-Long Beach, Calif.
220	BEA-166	Frenso, Calif.
221	BEA-167	Stockton, Calif.
222	BEA-168	Sacramento, Calif.
223	BEA-169	Redding, Calif.
224	BEA-170	Eureka, Calif.
225	BEA-171	San Francisco-Oakland, Calif.
226	BEA-172	Anchorage, Alaska
227	BEA-173	Honolulu, Hawaii

APPENDIX C

SAMPLE RATE QUOTATION FORMS

OUTBOUND CARGO
OVERLAND RATE

Commodity ____________ Col 1-4 [WCC Code] Col 8 [Direc] Col 11-17 [Sch A/B]

Tariff item description ____________

Port of ______ exit ____________ Col 9-11 [Code]

Import rate ______ Export rate ______ Domestic rate ______ Col 12 [I E D]

Rail ______ Truck ______ Barge ______ Col 13 [R T B]

General freight rate ______ Container rate ______ Col 14 [N C]

Commodity rate ______ Class rate ______ FAK rate ______ Col 15 [C L F]

Point of origin/	O/D Code	Minimum weight (lbs) (Use largest min.)	Rate (cents/cwt)	Extra fees (cents/cwt)	Citation
	Col 16-18	Col 19-22	Col 23-27	Col 28-32	

Comments:

APPENDIX C(3)

INBOUND CARGO
OVERLAND RATE

Commodity ____________ Col 1-4 [WCC Code] Col 8 [Direc] Col 34-37 [Sch A/B]

Tariff item description ____________

Port of entry/ ____________ Col 9-11 [Code]

Col 12
Import rate____ I
Export rate____ E
Domestic rate____ D

Col 13
Rail____ R
Truck____ T
Barge____ B

Col 14
General freight rate____ N
Container rate____ C

Col 15
Commodity rate____ C
Class rate____ L
FAK rate____ F

Point of destination	O/D Code	Minimum weight (lbs) (Use largest min.)	Rate (cents/cwt)	Extra fees (cents/cwt)	Citation
	Col 16-18	Col 19-22	Col 23-27	Col 28-32	

Comments:

DOMESTIC CARGO
OVERLAND RATE

Commodity ______ Col 1-4 [WCC Code] Col 8 [Direc] Col 34-37 [Sch A/B]

Tariff item description ______

Point of origin ______ Col 9-11 [Code]

	Col 12		Col 13		Col 14		Col 15
Import rate ____	I	Rail ____	R	General freight rate ____	N	Commodity rate ____	C
Export rate ____	E	Truck ____	T	Container rate ____	C	Class rate ____	L
Domestic rate ____	D	Barge ____	B			FAK rate ____	F

Point of destination	O/D Code	Type of Rate and Minimums	Rate (Cents Net Ton)		Citation
	Col 16-18		Col 23-27	Col 39	
		Unit Train:			
		Annual Volume:			
		Minimum Shipment (Tons or Cars):			

Comments:

OCEAN RATE

Direction ____________ Col 2

Commodity ____________ Col 4-7 Sch. A/B Code

Tariff item description ____________ Code — Sch. A/B / SITC / Other

Origin Port ____________ Col 10-12 Col 13 Code

Weight/measure units: Col 17

Short tons (2000 lb)	1
Long tons (2240 lb)	2
Metric tons (2204 lb)	3
Measure (40 cu. ft.)	4
Metric measurement (1 cu. meter)	5
W/M (metric)	7
W/M (short ton/measure)	8
W/M (long ton/measure)	9

Col 15

Contract	1
Non-contract	2

Col 16

Conference	1
Rate agreement	2
Independent	3

Destination port	Code		Rate		Extra fees	Shipping line/conference
			Container	Non-container		
	Col 19-21	22	Col 23-28	Col 29-34	Col 35-40	

Citation ____________

Comments:

APPENDIX D

TERMINAL CHARGES

AD-A054 630 BOOZ-ALLEN AND HAMILTON INC BETHESDA MD F/G 15/5
DEVELOPMENT OF A LOGISTICS PRICE FILE.(U)
OCT 77

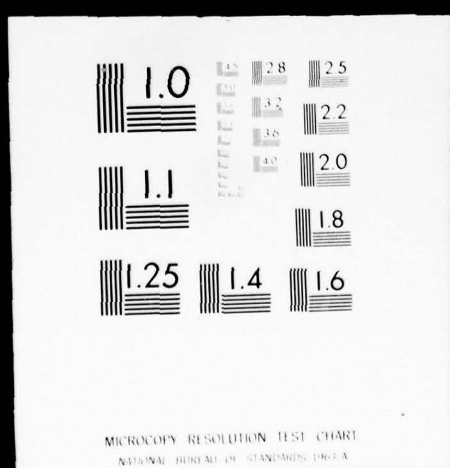
UNCLASSIFIED NL

2 OF 3
AD
A054630

ASSIFI

2 OF 3

AD
A054630



Handling and Transfer Charges at Great Lakes and (
(Expressed in Cents Per CWT)

BULK CARGO

Ports \ Commodity	Grains & Cereals[2]	Coal	Crude Oil/ Petroleum Products[1]	Limestone, Cement, Salt, Freeflowing Bulks	Ores & Concentrates	
Baltimore	.121	.131	.01	.131	.103	
Savannah	.178	—	.01	.089	—	
New Orleans	.180	.071	.01	.071	.071	
Long Beach/Portland	.115	.134	.01	.223	.134	
Buffalo	—	—	.01	.027	—	
Cleveland	.096	.036	.01	.116	.049	.(
Toledo	.096	.036	.01	.116	.049	.(
Detroit	.096	.036	.01	.116	.049	.(
Chicago	.096	.023	.01	.062	.083	.(
Milwaukee	.121	.080	.01	.062	.083	.(
Duluth	.121	Load .080 Disch. .060	.01	.062	.083	
Green Bay	.121	—	.01	.062	.083	

1 Ocean Ship/Pipeline Transfer Fee 1.03/BBL.

2 All grain handling charges include stevedoring

GENERAL CARGO

Ports \ Commodity	Container Drayage[1] To/From Rail	To/From Truck	Iron & Steel[5] To/From Rail	To/From Truck	Breakb To/Fro Rail
Baltimore	.060[2]	—	.170	.270	.145
Savannah	.077	.077	.118	.118	.240
New Orleans	.118	—	.266	.266	.161
Long Beach/Portland[3]	—	—	—	—	—
Buffalo	N/A[4]	N/A[4]	.26	.26	.26
Cleveland	.188	.188	.157	.157	.21
Toledo	.166	.166	.160	.160	.19
Detroit	.153	.153	.180	.140	.18
Chicago (Transoceanic Term)	.22	.22	.240	.240	.210
Milwaukee	.175	.175	.124	.100	.210
Green Bay	.205	.205	.106	.106	.230
Duluth	.179	.179	.190	.190	.235

1 Assumed 14 LT per 40 Ft. Container

2 Plan 2½:$19 per Container

3 Charges included in ocean tariff or absorbed by carriers.

4 No containers handled in Buffalo.

5 The charges for iron and steel products reflect a numeric average of the charges for all steel products listed in the terminal tariffs for each port.

APPENDIX D

andling and Transfer Charges at Great Lakes and Ocean Ports
(Expressed in Cents Per CWT)

BULK CARGO

Oil/ n Products[1]	Limestone, Cement, Salt, Freeflowing Bulks	Ores & Concentrates	Iron/Steel Scrap	Coke	Newsprint/Pulp (Liner Terms)	Other Bulks
01	.131	.103	.131	.131	.193	.131
01	.089	—	.140	—	.240	.065
01	.071	.071	.071	.071	.191	.088
01	.223	.134	.134	.134	—	.134
01	.027	—	—	—	—	—
01	.116	.049	.069(Dom).134(Int'l)	.061	.21	.116
01	.116	.049	.069(Dom).134(Int'l)	.061	.19	.116
01	.116	.049	.069(Dom).134(Int'l)	.061	.17	.116
01	.062	.083	.069(Dom).134(Int'l)	.061	—	.063
01	.062	.083	.069(Dom(.134(Int'l)	.061	.165	.083
01	.062	.083	.058	.061	.235	.083
01	.062	.083	.110	.061	.045	.083

ing

GENERAL CARGO

Container Drayage[1] To/From Rail	To/From Truck	Iron & Steel[5] To/From Rail	To/From Truck	Breakbulk (Prepalletized) To/From Rail	To/From Truck
.060[2]	—	.170	.270	.145	.193
.077	.077	.118	.118	.240	.240
.118	—	.266	.266	.161	.161
—	—	—	—	—	—
N/A[4]	N/A[4]	.26	.26	.26	.26
.188	.188	.157	.157	.21	.21
.166	.166	.160	.160	.19	.19
.153	.153	.180	.140	.18	.17
.22	.22	.240	.240	.210	.210
.175	.175	.124	.100	.210	.210
.205	.205	.106	.106	.230	.230
.179	.179	.190	.190	.235	.235

40 Ft. Container

ntainer

n ocean tariff or absorbed by carriers.

led in Buffalo.

on and steel products reflect a
the charges for all steel products
inal tariffs for each port.

2

APPENDIX E

RATE RANGE VARIANCE FACTORS

APPENDIX E
Rate Range Variance Factors

IMPORT				
Commod. Code	Great Lakes Route Break Bulk	Great Lakes Route Container	Competitive Route Break Bulk	Competitive Route Container
23	.111	.105	.051	.066
24	.663	.555	.065	.327
25	.369	.273	.258	.171
26	.234	.210	.210	.174
27	.213	.165	.216	.132
28	.165	.159	.117	.108
29	.204	.144	.120	.084
30	.210	.228	.174	.156
31	.195	.174	.168	.132
32	.204	.177	.168	.132
33	.240	-	.165	-
34	.060	-	.045	-
35	.024	-	.012	-
36	.051	-	.024	-
37	.003	-	.006	-
EXPORT				
23	.117	.096	.105	.075
24	.081	.078	.078	.066
25	.231	.177	.219	.159
26	.345	.300	.288	.240
27	.183	.159	.147	.120
28	.156	.120	.141	.111
29	.183	.159	.117	.090
30	.561	.513	.330	.291
31	.321	.249	.273	.213
32	.246	.210	.201	.156
33	.210	-	.189	-
34	.048	-	.033	-
35	.237	-	.111	-
36	.006	-	.009	-
37	.003	-	.003	-

APPENDIX F

DEVELOPMENT OF RATE CALCULATOR EQUATIONS

APPENDIX F

DEVELOPMENT OF RATE CALCULATOR EQUATIONS

This appendix documents the development of all rate calculator equations. The appendix is divided into six sections according to type and mode of transport:

- Rail
- Truck
- Barge
- Pipeline
- Lakewise water
- Ocean

1. RAIL

(1) General

It was initially assumed that distance along with value per ton of the cargo and stowage should explain most of the variations in rail freight rates. These variables were in many cases not sufficient in explaining the variation in freight rates, and a search for additional explanatory variables was started. A thorough check of the raw data revealed that there was a clear difference between class and commodity rates, where the class rates showed a pattern of being consistently higher than the commodity rates for the same commodities carried

over the same distance. Similarly, it was found that the rates for the same cargoes carried similar distances originating in or destined for the various rail rate territories were different. In the case of bulk cargoes rate differentials were observed between gravity and nongravity flow cargoes. Dummy variables representing these factors were introduced into the equations. These dummy variables were found to be statistically significant in most cases, and the goodness or fit improved significantly.

Rail rate territories are identified in Figure F-1. Many rail tariffs make reference to this geographic territory system.

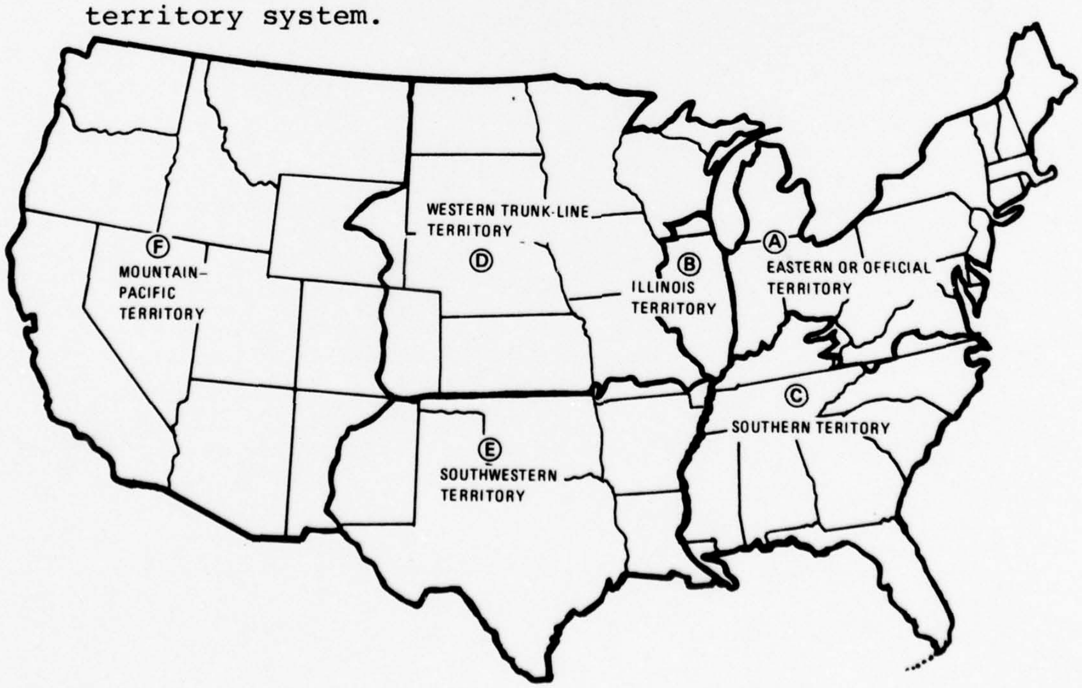


FIGURE F-1
Rail Rate Territories

Tariffs published by freight bureaus normally apply to movements involving origin and destination rate territories. On this basis "tariff areas" may be defined to identify combinations of territories covered by the same tariff. These tariff areas were used as dummy variables in the regression analysis and are defined in Figure F-2.

Origin Rate Territory \ Destination Rate Territory	A	B	C	D	F
A	5	5	5	5	1
B	5	4	4	2	1
C	3	3	3	3	1
D	2	2	2	2	1
F	1	1	1	1	1

NOTE: The Great Lakes hinterland of the Route Split Model does not include the Southwestern Rate Territory.

FIGURE F-2
Rail Tariff Areas

(2) Dry Bulk Cargoes

Of the bulk cargoes, three particular commodities exhibited a different rate behavior compared to the remaining bulk cargoes. These three were grain, coal and coke.

An equation was developed for single car grain cargoes, which exhibited a great degree of correlation with distance and rate territory. In the grain trade multiple car and unit train rates are becoming more prevalent. These rates are only applicable from selected BEA's to one or more of the Great Lakes or ocean ports. In was therefore decided to input directly into the model the actual unit train and multiple car rates between inland BEA's and ports where such rates were published.

The regression analysis of single car coal rates exhibited a linear relationship with distance and tariff area of origin. Multiple car and unit train shipments of coal is also becoming more common. Instead of adding the time consuming and costly effort to obtain a full set of unit train and multiple car rates, these rates were developed using ICC Ex Parte No. 270, (sub No. 4). "Investigation Of Railroad Freight Rate Structure - Coal" decided December 3, 1974. The report of these

hearings contain data indicating the rate differential between single car and multiple car/unit train rates in the different rail freight rate territories. The absolute rates in the report are at the present time out-dated. The relative difference between single car and multiple car rates, however, are assumed to be valid. The methodology to develop the multiple car coal rates was, therefore, to apply the mean percentage differential between the multiple car and single car rate developed from the data presented in Ex Parte 270 to the single car coal rail equation.

The rail freight rates for coke showed a pattern dramatically contrary to the rate behavior of the other bulk materials. Coke had a higher value per ton and higher stowage factor than most of the other bulk cargoes. Despite this fact, the freight rates for coke were lower than for any of the other cargoes. A prediction equation for coke was therefore developed separately from the other bulk materials. Coke was found to have a positive correlation with distance. Rate territory (tariff area) was not statistically significant.

The freight rates of the other bulk materials were positively correlated with distance, the gravity/non-gravity flow characteristic and the value per ton. Introduction of the stowage factor of the commodities

into the equation caused multi-colinearity with value per ton, and stowage was therefore excluded as an independent variable.

(3) Liquid Bulk Cargoes

Freight rates for four major refined petroleum products were selected for the sample as representative of this category. These products are gasoline, distillate fuel oil, residual fuel oil and asphalt. Tankcar rates were collected because this mode of transport is more prevalent than carriage in barrels or drums.

It was found that distance and value were the major explanatory variables and that the inclusion of dummy variables representing freight rate territories added to the explanation of the variation in freight rates.

A high degree of multicolinearity was found to exist between the stowage factor and value. The stowage factor had a lower coefficient of correlation with freight rate than the value per ton, and the stowage factor was therefore excluded from the equation.

(4) General Cargo

The freight rates for general cargo by rail showed a positive relationship with distance, value per ton, and the stowage factor in addition to the "dummy"

variables representive class/commodity rates and freight rate territory.

(5) <u>Freight All Kind (FAK) in Containers (TOFC/COFC)</u>

Rates for containerized rail shipments are generally quoted under two different types of rate schedules called Plan 2½ and Plan 3. For domestic U.S. shipments the only difference is that under Plan 2½ the cargo is shipped in railroad-owned containers, and the railroad therefore will position the empty containers free of charge. Containers shipped uner Plan 3 are shipper-owned and the railroad will assess a charge or fee for positioning the empty containers. The freight rates for Plan 3 are naturally lower than Plan 2½, since the cost to the railroad is lower.

An additional complicating factor is added, however, for intermodal container shipments moved by ocean liners in international trade. In these cases virtually all containers are owned or controlled by the steamship companies, and should be theoretically moved under Plan 3. Originally, all containers moved under Plan 2½, whereby the railroads positioned the empty containers free of charge by absorbing the positioning costs in the freight rate of moving the full container. This practice was recently halted by the Southern Railway

Freight Association, which despite protests from shippers, consignees and steamship companies started to move ocean container shipments under Plan 3 and assessed a positioning charge to position or pick up empty containers. The other railway freight associations are continuing to move containers under Plan 2-1/2.

Since rates were quoted under the different plans depending on the origin/destination of the cargo, it was necessary to include in the equation a dummy variable to explain the difference between the two plans.

Another factor complicating the analysis was the fact that freight rates were quoted either in terms of cost per forty-foot containerload or in terms of cost per hundredweight. It was therefore necessary to devise a method to convert all freight rates to a common cost base. That was accomplished by first assigning a dummy variable as the term of reference for the freight rate quotation. Freight rates in terms of cents per hundredweight were set at 0, while freight rates in terms of dollars per container were assigned the value of 1.

A basis for converting a per container cost to a hundredweight cost was then established. A series of regression runs were made using several alternative container capacities of between 10 and 20 long tons

per forty-foot container. The assumption was made that the best estimate of this conversion factor would be the one at which the coefficient of the dummy variable "0" would be close to or equal to zero as indicated by a statistically insignificant t-value equal to or very close to zero. This conversion factor was found to be 14 long tons.

Using this conversion factor a high correlation was found between freight rate as the dependent variable, and distance and the dummy variables for the freight rate plan (Plan 2 1/2 and Plan 3) and railroad tariff territories.

2. TRUCK

(1) Grain

The interstate movement of grains is not regulated, and rate data is therefore not available from public files. The states of Ohio and Minnesota have regulations defining the minimum rates that can be charged for intrastate shipments. In addition, a rate formula for grain by truck developed by Kansas State University was used.

To check the reasonableness of the rate formula developed from these three sources the director of traffic at the grain exchange in Minnesota was contacted. He reinforced the fact that truck grain rates fluctuate from day to day, and it is therefore difficult to give any guidance as to the rate structure. He indicated that the Minnesota intrastate rates could be used as a guideline to develop interstate rates. He also confirmed the fact that truck rates are generally lower than rail single car rates, a fact which was indicated by the rate equations. His reason for this was that truckers had to give grain shippers an incentive in the form of lower rates to compensate for the additional paper work required for shipping the same amount of grain compared to rail, and also for the fact that the loading gear had to be changed more frequently with truck compared to rail.

A major portion of the grain shipped to Duluth was transported by truck according to this source. Most of the grain shipments were restricted to distances of less than 200 miles, since longer distances would require the inconvenience of a possible overnight stay. However, he knew of several instances where grain was trucked more than 1,000 miles.

(2) General Cargo

The most significant variable in developing the rate function for general cargo by truck was distance. Other explanatory variables were the stowage factor and the dummy variable for class/commodity rates. The multiple regression was found to have a linear form.

(3) Freight All Kinds (FAK) in Containers

The truck function for containers was found to be a linear relationship between rate as the dependent variable and distance in miles as the independent variable.

3. BARGES

(1) Grain

The points from which grains can be shipped by barge are relatively limited. Rather than extracting a sample of freight rates and then developing a rate predictor function, the rates for the BEA's for which shipment by barge presented a viable alternative were collected. The tariff of Sioux City and New Orleans Barge Lines, Inc. was used as the representative tariff for the grain shipments on the Mississippi River and its tributaries.

(2) Coal

Large quantities of coal are shipped by barge on the inland waterways. In this study there were three possible barge shipment routes:

- From the Appalachian region via the Ohio River, up the Mississippi River and onto the Illinois waterway to Chicago and points on the lakes
- From the St. Louis area up the Mississippi River and the Illinois waterway to Chicago and points on the lakes.
- From western mines overland to the Mississippi River, up the Illinois waterway to Chicago and points on the lakes.

The American Waterways Operators, Inc., Sioux City and New Orleans Barge Lines, Inc., and several other barge operators were contacted. These operators indicated that coal from the Appalachian region to points on the lakes was moved exclusively by rail, since barges would not be competitive. In addition, all coal shipments by barge from points along the Mississippi from the St. Louis area to the Illinois waterway and along the Illinois waterway terminate in

Chicago. No coal is now moving from these origins by barge to points on the lakes.

Based on this information the only destination point for barge-susceptible coal in the study area was Chicago. However, the Route Split Model does not identify any coal shipments which terminate in the Chicago BEA. Consequently barge coal rates were not included in the LPF.

It should be noted that the survey of barge operators did identify current shipments of coal to the Chicago area. For example, Commonwealth Edison is receiving coal from Wyoming in unit train loads at their coal transloading plant at Havana, Illinois for transfer to barges operated by Valley Line for further transportation to their power plants in the Chicago area. This coal is moving under annual volume rail and barge rates. The reason for this transhipment arrangement is that the Commonwealth Edison plant in Chicago can receive coal only from barges.

4. PIPELINES

The pipeline mode of transportation is used extensively to transport crude petroleum to refineries located in the lakes region and petroleum products from refineries to major distribution points. Two different equations were developed for pipeline transportation: one for crude petroleum and one for refined petroleum products (gasoline, naphtha, fuel oil, etc.).* For crude petroleum distance was found to be the only statistically significant independent variable, while for refined products a dummy variable indicating an origin in the U.S. gulf region was found to be significant in addition to distance.

5. LAKEWISE WATER TRANSPORTATION

Lakewise water transportation was divided into four categories:

- Major dry bulks
- Minor dry bulks
- Grain
- Liquid bulk.

(1) Major Dry Bulks

Major bulk cargoes include coal, iron ore and limestone. The rates for these cargoes were obtained from Pickands Mather & Co. of Cleveland, Ohio for

* Pipeline diameter was not identified in the tariffs.

movement in their large lake bulk carries (20,000 to 30,000 DWT). The rates were extracted directly from the rate quotations obtained for the origins and distinations applicable.

(2) Minor Dry Bulks

The lakewise freight rates for the minor bulk cargoes, which included all free-flowing dry bulk commodities other than the above major bulks, were obtained from American Steamship Company of Buffalo, N.Y. It was assumed that the predominant ship type used for moving these cargoes are a self-unloading vessel of 530-foot length, 60-foot beam, 21-foot draft, with a payload of minimum 11,000 short tons. The rates used in the sample were based on 12 hour loading time and 10 hours unloading time. The only independent variable used in developing the equation was distance.

(3) Grain

Grain is moved between a limited number of origins and destinations on the Great Lakes. The lakewise freight rates for grain shipments were obtained from the St. Lawrence Seaway Development Corp. and were input directly into the model.

(4) Petroleum Products

The number of origins and destinations between which petroleum products could be transported on the

lakes are limited. Canadian law prevents U.S. flag tankers from carrying petroleum between Canadian points. Since a major portion of petroleum products are moved between Canadian points, rate quotations were requested from two Canadian companies as well as a major U.S tanker company operating on the Great lakes. Rate quotations were provided by:

- Branch Lines, Ltd., Sorel, Canada
- Hall Corporation Shipping Ltd., Toronto, Canada
- Cleveland Tankers, Inc., Cleveland, Ohio.

These rates correspond to tankers of about 3,000 to 4,000 DWT.

Freight rates were obtained for gasoline, distillate and residual fuel oils. For carriage by Canadian and U.S. tankers, the analysis indicated that distance explains sufficiently the rate levels.

6. OCEAN TRANSPORTATION

(1) Grain

We found that statistically significant independent variables explaining variation in ocean freight rates of grain were the shipment lot size, distance and dummy variables representing the U.S. port range

from which the grains were shipped. No grain shipments were reported from the South Atlantic region.

A premium rate was found to be required for shipments originating in the Great Lakes compared to the other coastlines. The lowest rates were obtained from the St. Lawrence River, followed by the Gulf Coast, North Atlantic Coast and the West Coast. The stowage factor or value of the various grains had no significance in explaining the freight rates.

(2) Other Bulk Materials

It was found that the ocean rates for all other bulk materials carried in a free-flowing state in the ship's hold were determined by the distance traveled and the size of the shipment. The different stowage factors and different values of the various commodities had no significance in the determination of the freight rates. No charter fixtures were reported for shipments either into or out of the Great Lakes, and the dummy variables inserted to represent the other coastlines were statistically insignificant.

(3) Liquid Bulk Cargoes

Ocean charter rate data was obtained for the international trade routes in question from "Worldscale".

It was assumed that all international liquid bulk cargoes would be carried in clean/dirty product tankers of 25,000 DWT. Under the depressed market conditions currently prevailing in the tanker market, it was calculated that a tanker of this size would command a rate of WS 141, ie., 141% of the Worldscale flat rate. This was derived from the following formula:

$$\log \frac{WS}{100} = 1.09349 - 0.81286 \log \frac{\text{ship DWT}}{10{,}000}$$

Tanker rates at WS 141 for the applicable trade routes were input to the LPF.

(4) General Cargo

Several factors influence the level of liner rates. These factors include:

- Stowage factor
- Value per ton
- Distance
- Competition from non-conference carriers, neobulk operators (i.e., non-scheduled or semi-scheduled operators that carry liner type cargoes in large lot sizes on a voyage or long term charter basis)
- Competition from other coastlines
- Strength of conferences and rate agreements

- Quantities and lots sizes of various commodities shipped.

With the exception of stowage factor, value and distance, it would be virtually impossible to obtain reliable, quantifiable data points or create dummy variables to include these variables into the regression analysis. In order to develop rate predictor functions which reflect these factors, various groupings of U.S. coastlines and world areas were tested using stowage factor, value and distance as the independent variables with freight rate as the dependent variable. All reasonable levels of aggregation were tested.

In addition, imports and exports were analyzed separately. The reasons for making this distinction are:

- Export commodities are generally different from those being imported, and the rate structure of export trades are different from that of import trades.

- The values of commodities with the same SITC number are often different for import and export trades. Since value is one of the

important explanatory variables, this fact might bias the results.

It was found that the freight rates are structured to a very large extent along the trade areas of the various freight conferences, and that great differences existed in the freight rate structure between these freight conferences. In most cases the regressions to derive freight rate predictors for the ocean liner trade had to be structured along combinations of U.S. coastlines and foreign areas as defined by various liner freight conferences. This detailed definition and fine breakdown of trade areas naturally required the development of a multitude of equations to account for all different combinations.

Since a large number of equations were developed, the sample size for some trade routes was small (10 or less). For the most part this occurred in the trades which are comparatively minor for the Great Lakes Hinterland. To ensure that the equation developed from a statistically small sample was valid, the general form of the equation was checked against the equations for trade areas for which the rate structure was expected to be comparable. In addition, if a satisfactory r^2 could not be developed, the sample size was increased.

With very few expections it was found that distance was not statistically significant. In some cases multicolinearity was found to exist between stowage factor and value per ton. In those cases the variable with less correlation to the freight rate was eliminated.

For some combinations of U.S. coastlines and foreign areas no liner service was available. Tables F-1 and F-2 summarize the assumptions made with respect to filling in equations for these potential trade routes.

In the cases of exports from the U.S. Great Lakes to the Middle East (Area O) and imports to U.S. Great Lakes from Caribbean, Central America and Mexico (Areas F, G, H), the relative rate differential between the Great Lakes and the alternate U.S. coast for the trade routes to neighboring areas with relatively similar freight rate structures was used. These rate differentials were then applied to the calculated rates for the two missing trades, and equations were derived from the calculated rates.

7. TERMINAL AND HANDLING CHARGES FOR GREAT LAKES AND OCEAN SHIPMENTS

The terminal and handling charges applicable to bulk and general cargoes differ. For bulk cargoes the shippers or consignees of the cargoes are normally responsible for

TABLE F-1
Ocean Export Freight Rates

Assumptions Used in Developing Freight Rates for Trades with No Liner Service or Which Are Served By Liners from Other Trades

U.S. Coastline	Foreign Area	Assumption
GL	G-Central America	Freight rates are equal to rates from GL to Caribbean
GL	H-Mexico	-Same as above-
ATL/GULF	H-Mexico	The freight rates are equal to rates from ATL/GULF to Caribbean
GL/ATL/GULF	L-North Africa	These trade routes are served by the same liner operators that serve Mediterranean Europe. Rates assumed to be similar.
GL	O-Middle East	Rate equation was developed based on the rate structure of ATL/GULF to Middle East and the differential between the rate for GL to East Asia and ATL/GULF to East Asia
GL/ATL/GULF/PACIFIC	S-Communist Asia	Freight rates are the same as to East Asia
GL/ATL/GULF	U-Communist Europe	Freight rates are the same as to North Europe
GL	V-Oceania	Freight rates would be the same as to East Asia and South Asia (particularly Southeast Asia), because 1) Trades have very similar characteristics, both in terms of import and export commodities, and 2) Trade imbalances in both trades favor exports, while a relatively few raw or semiprocessed materials are shipped out.

TABLE F-2
Ocean Import Freight Rates

Assumptions Used in Developing Freight Rates for
Trades with Liner Service, or
Which are Served by Liners from Other Trades

U.S. Coastline	Foreign Area	Assumption
GL	E-Western South America	Freight rates are equal to rates to GL from eastern South America
GL	F,G,H-Caribbean Central America/ Mexico	Rate equation was developed based on the rate structure of Carribbean and Central America to ATL/GULF and the differential between the rates for eastern South America to GL and to ATL/GULF.
GL/ATL/GULF	L-North Africa	These trade routes are served by the same liner operators that serve Mediterranean Europe. Rates assumed to be similar to Mediterranean Europe trades
GL/ATL/GULF/ PACIFIC	S-Communist Asia	Freight rates are the same as to East Asia
GL/ATL/GULF	U-Communist Europe	Freight rates are the same as to North Europe
GL	V-Oceania	Freight rates would have been similar to rates from East and South Asia (not Japan) because 1) Trades have similar characteristics 2) Trade imbalances exist in both trades. Export predominates, while imports consist of relatively few raw and semiprocessed materials

the payment of all terminal and stevedoring costs, to load or discharge the vessels and for transferring the cargoes between the ship and the inland mode of transportation, ie., truck, rail or barge. For general cargo the shippers and consignees are only responsible for the costs of transfering the cargoes to or from the inland mode of transportation, while the steamship company will pay the remaining charges. Only the data on the terminal and handling charges that were payable by shipper and consignees was collected.

Data were collected for the following ports:

Great Lakes Ports	Ocean Ports
Duluth	Baltimore
Green Bay	Savannah
Milwaukee	New Orleans
Chicago	Long Beach
Detroit	
Toledo	
Cleveland	
Buffalo	

The organizations that were contacted to obtain the information included:

- The port authorities in each port
- One or more stevedoring companies in each port
- Grain trading houses and elevator companies

- Railroads that operate bulk handling facilities (B&O in Baltimore, Conrail in Toledo)

- Shippers and consignees of bulk cargoes

In the case where it was not possible to obtain handling charges for one cargo type for one or more ports, it was assumed that charges for the same cargo at neighboring ports would be a reasonable approximation for the rates at that port.

(1) Bulk Cargoes Transported between Points on the Great Lakes

The charges and rates for handling of bulk commodities are in most cases negotiable, and are thus subject to a multitude of variables. The stevedores were asked to indicate rates that would be charged in the majority of cases.

In virtually all conversations concerning bulk shipments on the Great Lakes with port authorities, es, stevedores and ship operators, it was stressed that a major portion of the bulk shipments originate from shipper owned terminals and are destined for consignee-owned terminals. Furthermore many of these cargoes are carried in self-unloaders. There are therefore no specific handling charges as such involved. The loading and discharge equipment is owned and operated by the

owners of the cargoes, and they do not account for the loading and discharge costs as such. These costs are an integral part of their overall operation.

Under normal circumstances bulk shipments on the Great Lakes are incurring handling and stevedoring charges only at public use terminals, and only when they are transferred between inland modes of transportation and lakewise bulk carriers.

Based on these observations, the assumption was made that only Great Lake shipments originating at and/or being destined for inland points with intermediate shipping by Great Lakes carriers would be subject to handling charges at the port or ports of transfer the amount of the transloading charges between the lakecarrier and the inland mode (rail or truck). Shipments in lake carriers between points on the Great Lakes would not be subject to handling charges.

(2) Bulk Cargoes Transported to/from International Destinations/Origins

These cargoes are normally handled at public terminals, and in most cases the charges for most of the cargo groups were obtained from applicable tariffs.

(3) <u>General Cargo Transported to/from International Destinations/Origins</u>

The port tariffs covering these shipments are in some cases very detailed giving individual rates for virtually all types of cargoes. The following rules were used in applying the handling charges:

- Breakbulk cargoes were defined as being palletized or skidded cargoes. In most cases one rate is given for these cargoes.

- Iron and steel products usually had several alternative rates. A numeric average of all the listed rates was used.

- Forty-foot containers were used as the standard size for collecting container handling charges.

APPENDIX G

STATISTICAL ANALYSES

APPENDIX G(1)

RATE CALCULATOR EQUATIONS

OCEAN LINER RATES

DEFINITION OF TERMS:

OCEAN LINER RATE EQUATIONS

RATE = Freight rate, \$/LT (long ton)

STOW = Stowage factor, (40 ft^3/LT = 1.00)

VALT = Value per ton (\$/LT)

DIST = Distance (N.M.)

Functions of these parameters:

```
RATELN = LN (RATE)
RATEIN = 1/RATE
DISTLN = LN (DIST)
DISTIN = 1/DIST
DISTSQ = SQRT (DIST)
DISTEX = EXP (DIST/1000)
DISTP2 = DIST**2/100
DISTP3 = DIST**3/100
DISTI2 = 1/DISTP2
DISTI3 = 1/DISTP3
DISTIS = 1/DISTSQ
VALTLN = LN (VALT)
VALTSQ = SQRT (VALT)
VALTEX = EXP (VALT/100)
VALTP2 = VALT**2/100
VALTP3 = VALT**3/100
VALTIN = 1/VALT
VALTI2 = 1/VALTP2
VALTI3 = 1/VALTP3
VALTIS = 1/VALTSQ
STOWLN = LN (STOW)
STOSQ  = SQRT (STOW)
STOWEX = EXP (STOW/10)
STOWP2 = STOW**2/100
STOWP3 = STOW**3/100
STOWIN = 1/STOW
STOWI2 = 1/STOWP2
STOWI3 = 1/STOWP3
STOWIS = 1/STOSQ
```

APPENDIX G(3)

RATE CALCULATOR EQUATIONS

IMPORTS

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Eastern South America

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = .11784185 (VALT) - 6.8388242
(8.91)

F - VALUE: 79.46594

r : .96426

r^2 : .92980

STANDARD DEVIATION: 42.71343

N OF CASES: 9

FUNCTION, CONTAINERIZED: RATE = .11069935 (VALT) - 1.8571036
(9.32)

F - VALUE: 86.90805

r : .96717

r^2 : .93542

STANDARD DEVIATION: 38.36812

N OF CASES: 9

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Eastern and Western South America

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = .068624378 (VALT) + 27.160925
(9.23)

F - VALUE: 52.21254

r : .90884

r^2 : .82598

STANDARD DEVIATION: 50.76199

N OF CASES: 13

FUNCTION, CONTAINERIZED: RATE = .06189753 (VALT) + 24.410569
(6.98)

F - VALUE: 48.80391

r : .90336

r^2 : .81607

STANDARD DEVIATION: 47.29853

N OF CASES: 13

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Caribbean and Central America

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 44 (VALTLN) + 216.5

F - VALUE:

r : NA - relationship was constructed based on trades on other similar trade routes.

r^2 : No service is offered on this trade route.

STANDARD DEVIATION:

N OF CASES:

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Caribbean and Central America

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATEIN = 12397.081 (VALTI3) + 0.010535667
(3.29)

F - VALUE: 10.83896

r : .85466

r^2 : .73044

STANDARD DEVIATION: .00202

N OF CASES: 6

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Caribbean and Central America

U.S. COASTLINES: Miami

FUNCTION, BREAK-BULK: RATE = 1606.1544 (STOWP2) + 23.165098
(5.58)

F - VALUE: 31.11431

r : .94132

r^2 : .88609

STANDARD DEVIATION: 17.84035

N OF CASES: 6

FUNCTION, CONTAINERIZED: RATE = 319.58204 (STOWEX) - 310.14811
(2.27)

F - VALUE: 5.13583

r : .60276

r^2 : .36332

STANDARD DEVIATION: 36.72036

N OF CASES: 6

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Northern Europe, United Kingdom, Communist Europe

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 70.825402 (STOW) + .030530037 (VALT) -21.193590
(6.08) (2.46)

F - VALUE: 41.83323

r : .87746

r^2 : .76994

STANDARD DEVIATION: 91.57755

N OF CASES: 36

FUNCTION, CONTAINERIZED: RATE = 62.675638 (STOW) + 5.3498081
(7.11)

F - VALUE: 50.55102

r : .79219

r^2 : .62757

STANDARD DEVIATION: 79.97467

N OF CASES: 36

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Northern Europe and Communist Europe

U.S. COASTLINES: U.S. Atlantic

FUNCTION, BREAK-BULK: RATE = 42.236811 (STOW) + 0.012864571 (VALT) +64.201886
(4.29) (2.81)

F - VALUE: 20.47398

r : .79402

r^2 : .63047

STANDARD DEVIATION: 84.80816

N OF CASES: 27

FUNCTION, CONTAINERIZED: RATE = .014252407 (VALT) + 27.026368 (STOW) +64.985793
(3.79) (3.34)

F - VALUE: 20.29758

r : .79275

r^2 : .62846

STANDARD DEVIATION: 69.66772

N OF CASES: 27

COMMENTS:

Break bulk equation may not be valid for stowage factors less than 0.70.

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Northern Europe

U.S. COASTLINES: U.S. Gulf

FUNCTION, BREAK-BULK: RATE = .04810089 (VALT) + 42.748927
(7.69)

F - VALUE: 59.14402

r : .93854

r^2 : .88085

STANDARD DEVIATION: 29.84606

N OF CASES: 11

FUNCTION, CONTAINERIZED: RATE = .046976557 (VALT) + 37.179400
(8.09)

F - VALUE: 65.45589

r : .93762

r^2 : .87912

STANDARD DEVIATION: 27.89293

N OF CASES: 11

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Mediterranean Europe

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 0.047819664 (VALT) + 71.883483
(6.74)

F - VALUE: 45.55122

r : .86026

r^2 : .74005

STANDARD DEVIATION: 34.46383

N OF CASES: 18

FUNCTION, CONTAINERIZED: Same as above

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Mediterranean Europe

U.S. COASTLINES: U.S. North Atlantic

FUNCTION, BREAK-BULK: RATE = 0.027759121 (VALT) + 12.535174 (STOW) +42.761984
(3.35) (2.06)

F - VALUE: 18.24658

r : .88601

r^2 : .78501

STANDARD DEVIATION: 26.38998

N OF CASES: 15

FUNCTION, CONTAINERIZED: RATE = .030050325 (VALT) + 13.863611 (STOW) +49.208205
(3.28) (1.91)

F - VALUE: 16.82915

r : .87804

r^2 : .77095

STANDARD DEVIATION: 29.19150

N OF CASES: 15

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Mediterranean Europe

U.S. COASTLINES: U.S. South Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 40.916670 (STOW) + 60.405441
(6.72)

F - VALUE: 45.17933

r : .89677

r^2 : .80420

STANDARD DEVIATION: 31.45151

N OF CASES: 13

FUNCTION, CONTAINERIZED: RATE = 43.846937 (STOW) + 59.842712
(6.92)

F - VALUE: 47.92331

r : .90184

r^2 : .81332

STANDARD DEVIATION: 32.72479

N OF CASES: 13

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: United Kingdom

U.S. COASTLINES: U.S. Atlantic

FUNCTION, BREAK-BULK: RATE = 1945.4222 (STOWP2) + 85.835522
(9.92)

F - VALUE: 85.02404

r : .95603

r^2 : .91400

STANDARD DEVIATION: 54.41246

N OF CASES: 10

FUNCTION, CONTAINERIZED: RATE = 311.60564 (STOWP3) + 111.97936
(9.78)

F - VALUE: 95.67144

r : .96064

r^2 : .92283

STANDARD DEVIATION: 47.13320

N OF CASES: 10

COMMENTS: NOTE: The relationship is not valid for stowage factors above 6.0.

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: United Kingdom

U.S. COASTLINES: U.S. Gulf

FUNCTION, BREAK-BULK: RATE = 110.00788 (STOW) - 33.520562
(6.67)

F - VALUE: 44.49504

r : .92065

r^2 : .84760

STANDARD DEVIATION: 68.80431

N OF CASES: 10

FUNCTION, CONTAINERIZED: RATE = 110.07033 (STOW) - 36.993901
(6.66)

F - VALUE: 44.41653

r : .92053

r^2 : .84738

STANDARD DEVIATION: 68.90418

N OF CASES: 10

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Developing Africa and South Africa

U.S. COASTLINES: Great Lakes, U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 0.0056810964 (DISTEX) + 45.656129 (STOW) +35.287104
(2.96) (2.23)

F - VALUE: 9.26634

r : .73258

r^2 : .53667

STANDARD DEVIATION: 71.54935

N OF CASES: 19

FUNCTION, CONTAINERIZED: RATE = .0048818466 (DISTEX) + 49.092438 (STOW) +39.354197
(2.85) (2.24)

F - VALUE: 8.83992

r : .72453

r^2 : .52494

STANDARD DEVIATION:

N OF CASES: 19

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Middle East

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = .0052609532 (VALT) + 179.90
(.89)

F - VALUE: 30.93860

r : .94782

r^2 : .89837

STANDARD DEVIATION: 42.58420

N OF CASES: 10

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Japan

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 124.96228 (STOW) -2.2723611
(34.62)

F - VALUE: 1198.67824

r : .99421

r^2 : .98846

STANDARD DEVIATION: 55.77854

N OF CASES: 16

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Japan

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 492.42645 (STOWEX) -378.42667
(30.88)

F - VALUE: 953.69615

r : .99274

r^2 : .98553

STANDARD DEVIATION: 66.59246

N OF CASES: 16

FUNCTION, CONTAINERIZED: RATE = 477.99340 (STOWEX) -368.23085
(30.44)

F - VALUE: 926.46836

r : .99253

r^2 : .98511

STANDARD DEVIATION: 65.58360

N OF CASES: 16

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Japan

U.S. COASTLINES: U.S. Pacific

FUNCTION, BREAK-BULK: RATE = 409.23265 (STOWEX) -307.19252
(26.79)

F - VALUE: 717.86290

r : .99039

r^2 : .98087

STANDARD DEVIATION: 63.78789

N OF CASES: 16

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: South Asia and East Asia

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 522.32225 (STOWEX) -491.17433
(10.85)

F - VALUE: 117.85142

r : .96387

r^2 : .92905

STANDARD DEVIATION: 41.16783

N OF CASES: 11

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: East Asia

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 72.177025 (STOW) +8.3124018
(9.15)

F - VALUE: 83.87277

r : .94524

r^2 : .89347

STANDARD DEVIATION: 52.26710

N OF CASES: 12

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: East Asia

U.S. COASTLINES: U.S. Pacific

FUNCTION, BREAK-BULK: RATE = 66.633933 (STOW) + 13.610344
(6.71)

F - VALUE: 45.02489

r : .92148

r^2 : .84913

STANDARD DEVIATION: 56.16685

N OF CASES: 10

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: South Asia

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 133.53316 (STOW) -42.565498
(7.38)

F - VALUE: 54.41591

r : .92633

r^2 : .85808

STANDARD DEVIATION: 118.26137

N OF CASES: 11

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

IMPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Oceania

U.S. COASTLINES: U.S. Atlantic, Gulf and Pacific

FUNCTION, BREAK-BULK: RATEIN = .0059434939 (STOWIS) + .0042989719
(3.37)

F - VALUE: 11.41234

r : .83388

r^2 : .69535

STANDARD DEVIATION: .00380

N OF CASES: 7

FUNCTION, CONTAINERIZED: Ratein = .0064112537 (STOWIS) + .0042735798
(3.28)

F - VALUE: 10.79709

r : .82673

r^2 : .68349

STANDARD DEVIATION: .00421

N OF CASES: 7

COMMENTS:

RATE CALCULATOR EQUATIONS

EXPORTS

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: East Coast of South America

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 1583.3703 (STOWP2) + 104.64380
(3.42)

F - VALUE: 11.66922

r : 71747

r^2 : .51476

STANDARD DEVIATION: 70.36390

N OF CASES: 13

FUNCTION, CONTAINERIZED: RATE = 1579.0739 (STOWP2) + 105.38349
(3.41)

F - VALUE: 11.63710

r : .71699

r^2 : .51407

STANDARD DEVIATION: 70.26976

N OF CASES: 13

COMMENTS: NOTE - Relationships may not be valid for stowage factors over 5.0.

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: East Coast of South America

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 83.825744 (STOW) + 0.012465541 (VALT) + 7.0851204
(6.02) (1.96)

F - VALUE: 23.83852

r : .80995

r^2 : .65601

STANDARD DEVIATION: 66.93334

N OF CASES: 15

FUNCTION, CONTAINERIZED: RATE = 83.766326 (STOW) + 0.011904804 (VALT) + 8.4533931
(6.18) (1.92)

F - VALUE: 24.83213

r : .81558

r^2 : .66517

STANDARD DEVIATION: 65.12386

N OF CASES: 15

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: West Coast South America

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = .062290601 (VALT) + 76.270553
(3.57)

F - VALUE: 12.75

r : .82465

r^2 : .68005

STANDARD DEVIATION: 85.31909

N OF CASES: 8

FUNCTION, CONTAINERIZED: Same as above

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: West Coast of South America

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 74.558957 (STOW) + 51.567832
(8.69)

F - VALUE: 75.43155

r : .96842

r^2 : .93784

STANDARD DEVIATION: 34.19130

N OF CASES: 7

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Caribbean

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 1429.0468 (STOWP2) + 80.063433
(8.41)

F - VALUE: 70.79278

r : .96014

r^2 : .92187

STANDARD DEVIATION: 29.58453

N OF CASES: 8

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS: No rates are available for Central America. This function can also be used for the Central American region.

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Caribbean and Central America

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 69.746178 (STOW) + 24.091247
(12.84)

F - VALUE: 164.75681

r : .90367

r^2 : .81661

STANDARD DEVIATION: 41.55028

N OF CASES: 30

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Caribbean

U.S. COASTLINES: Miami, Florida

FUNCTION, BREAK-BULK: RATE = 41.902570 (STOW) + 51.190831
(5.25)

F - VALUE: 27.56576

r : .81436

r^2 : .66318

STANDARD DEVIATION: 39.98649

N OF CASES: 13

FUNCTION, CONTAINERIZED: RATE = 22.096085 (STOW) + 59.256906
(3.41)

F - VALUE: 11.63

r : .67371

r^2 : .45389

STANDARD DEVIATION: 32.45461

N OF CASES: 13

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: North Europe, U.K. and Communist Europe

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 71.341955 (STOW) + 38.344530
(18.08)

F - VALUE: 327.00250

r : .96111

r^2 : .92373

STANDARD DEVIATION: 35.36746

N OF CASES: 37

FUNCTION, CONTAINERIZED: RATE = 38.682005 (STOW) + 43.023402
(6.26)

F - VALUE: 39.25284

r : .72707

r^2 : .52864

STANDARD DEVIATION: 56.68257

N OF CASES: 37

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: North Europe, Communist Europe

U.S. COASTLINES: U.S. Atlantic

FUNCTION, BREAK-BULK: RATE = 1.9741782 (VALTSQ) + 59.703238 (STOW) + 10.867002
(7.82) (5.93)

F - VALUE: 92.41783

r : .92115

r^2 : .84851

STANDARD DEVIATION: 35.02856

N OF CASES: 39

FUNCTION, CONTAINERIZED: RATE = 1.9480293 (VALTSQ) + 36.649240 (STOW) + 19.322566
(7.95) (3.75)

F - VALUE: 69.41751

r : .89886

r^2 : .80796

STANDARD DEVIATION: 34.00884

N OF CASES: 39

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: North Europe

U.S. COASTLINES: U.S. Gulf

FUNCTION, BREAK-BULK: RATE = 51.990479 (STOW) + .011309677 (VALT) + 28.748275
(3.67) (2.23)

F - VALUE: 26.78637

r : .91799

r^2 : .84270

STANDARD DEVIATION: 40.57654

N OF CASES: 13

FUNCTION, CONTAINERIZED: RATE = 53.996222 (STOW) + 011367552 (VALT) + 25.348205
(3.60) (2.11)

F - VALUE: 25.25374

r : .91364

r^2 : .83473

STANDARD DEVIATION: 42.90538

N OF CASES: 13

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Mediterranean Europe

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATELN = .30740810 (STOW) + .0072698040 (VALTSQ) + 4.0509766
(3.80) (2.44)

F - VALUE: 15.68884

r : .83155

r^2 : .69148

STANDARD DEVIATION: .30231

N OF CASES: 17

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Mediterranean Europe

U.S. COASTLINES: U.S. North Atlantic

FUNCTION, BREAK-BULK: RATELN = .30203739 (STOW) + .010445140 (VALTSQ) + 3.987
(3.95)
(3.39)

F - VALUE: 19.94372

r : .89417

r^2 : .79955

STANDARD DEVIATION: .31028

N OF CASES: 18

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Mediterranean Europe

U.S. COASTLINES: U.S. South Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 2.9228440 (VALTSQ) + 71.002417 (STOW) -32.34850
(6.15) (4.55)

F - VALUE: 46.04924

r : .93169

r^2 : .86805

STANDARD DEVIATION: 50.7

N OF CASES: 17

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: United Kingdom

U.S. COASTLINES: U.S. Atlantic

FUNCTION, BREAK-BULK: RATE = .011081017 (VALT) + 64.501578 (STOW) + 53.210878

(3.88) (3.71)

F - VALUE: 26.10496

r : .85031

r^2 : .72303

STANDARD DEVIATION: 36.56283

N OF CASES: 25

FUNCTION, CONTAINERIZED: RATE = .0095197564 (VALT) + 50.160766 (STOW) + 48.146796

(3.74) (3.26)

F - VALUE: 22.82704

r : .82147

r^2 : .67482

STANDARD DEVIATION: 38.85989

N OF CASES: 25

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: United Kingdom

U.S. COASTLINES: U.S. Gulf

FUNCTION, BREAK-BULK: RATE = 3.5139869 (VALTSQ) + 36.197084
(4.49)

F - VALUE: 20.19072

r : .80457

r^2 : .64377

STANDARD DEVIATION: 66.30680

N OF CASES: 14

FUNCTION, CONTAINERIZED: RATE = 3.5582799 (VALTSQ) + 33.177277
(5.03)

F - VALUE: 25.32094

r : .82369

r^2 : .67846

STANDARD DEVIATION: 63.97457

N OF CASES: 14

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Middle East

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 149.1 (STOWLN) + 179.86

F - VALUE:)
r :)
r^2 :)

N.A. - Relationship was constructed based on rates on other similar trade routes

STANDARD DEVIATION:

N OF CASES:

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Middle East

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 149.32660 (STOWLN) + 170.00802
(6.28)

F - VALUE:39.39155

r :.92147

r^2 :.84911

STANDARD DEVIATION: 44.09525

N OF CASES: 9

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Developing Africa and South Africa

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 155.61232 (STOW) -43.971359
(8.96)

F - VALUE: 80.31585

r : .90383

r^2 : .81692

STANDARD DEVIATION: 71.32441

N OF CASES: 20

FUNCTION, CONTAINERIZED: RATE = 157.26570 (STOW) -38.048737
(8.90)

F - VALUE: 79.14429

r : .90261

r^2 : .81471

STANDARD DEVIATION: 72.61379

N OF CASES: 20

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Developing Africa and South Africa

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 109.22970 (STOW) + 11.349265
(8.49)

F - VALUE: 72.13616

r : .88007

r^2 : .77452

STANDARD DEVIATION: 61.61746

N OF CASES: 23

FUNCTION, CONTAINERIZED: RATE = 106.37708 (STOW) + 8.0672052
(9.48)

F - VALUE: 89.89530

r : .90035

r^2 : .81063

STANDARD DEVIATION: 53.75503

N OF CASES: 23

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: South Asia, East Asia and Japan

U.S. COASTLINES: Great Lakes

FUNCTION, BREAK-BULK: RATE = 834.31689 (STOWEX) -1797.2745 (VALTIS) -734.02264
(13.11) (5.04)

F - VALUE: 158.48354

r : .97422

r^2 : .94910

STANDARD DEVIATION: 28.17851

N OF CASES: 20

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS:

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Japan

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATELN = 1.3977217 (STOSQ) -23.756651(VALTIS) +4.0713609
(6.97) (5.64)

F - VALUE: 45.41842

r : .95386

r^2 : .90985

STANDARD DEVIATION: .18548

N OF CASES: 12

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS: Note: Relationship may not be valid for stowage factors above 6.0.

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Japan

U.S. COASTLINES: U.S. Pacific

FUNCTION, BREAK-BULK: RATELN = 1.2339340 (STOSQ) -336.96558 (VALTIN) + 3.9596970
(11.02) (9.58)

F - VALUE: 118.05455

r : .98147

r^2 : .96328

STANDARD DEVIATION: .10375

N OF CASES: 12

FUNCTION, CONTAINERIZED: Same as above.

F - VALUE:

r :

r^2 :

STANDARD DEVIATION:

N OF CASES:

COMMENTS: NOTE: Relationship may not be valid for stowage factors above 6.0 and very high VALVER per ton figures.

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: South Asia and East Asia

U.S. COASTLINES: U.S. Atlantic and Gulf

FUNCTION, BREAK-BULK: RATE = 1038.1725 (STOWEX) + .013324268 (VALT) -1022.4354
(6.54) (2.26)

F - VALUE: [illegible]

r : [illegible]

r^2 : [illegible]

STANDARD DEVIATION: [illegible]

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: East Asia

U.S. COASTLINES: U.S. Pacific

FUNCTION, BREAK-BULK: RATELN = 7.2890598 (STOWP2) + .24712378 (VALTLN) + 3.1527
(3.99) (2.78)

F - VALUE: 16.20050

r : .86737

r^2 : .75233

STANDARD DEVIATION: [illegible]

OF CASES: [illegible]

[illegible]

EXPORTS - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: Oceania

U.S. COASTLINES: U.S. Atlantic, Gulf and Pacific

FUNCTION, BREAK-BULK: RATEIN = .00008893193 (STOWI3) + .0025927670
(4.67)

F - VALUE: 21.86162

r : .78078

r^2 : .60961

STANDARD DEVIATION: .00109

N OF CASES: [illegible]

RATE CALCULATOR EQUATIONS

OCEAN BULK CHARTER RATES

OCEAN BULK CHARTER RATES - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS:)
) Great Lakes
U.S. AREAS:)

COMMODITIES: All bulk materials (by lakes self-unloaders)

FUNCTION: IRATIN = 32.919559 (DISTIN) + .11612118
(17.58)

F - VALUE: 309.16768

r : .98267

r^2 : .96564

STANDARD DEVIATION: .01484

N OF CASES: 13

COMMENTS: IRATIN = Inverse of freight rate (per short ton)
DISTIN = Inverse of distance in statute miles

OCEAN BULK CHARTER RATES - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: All

U.S. AREAS: All

COMMODITIES: All grains and cereals

FUNCTION: IRATLN = -.000018731585 (LSIZE) +.011845345 (DISTSQ)
(12.96) (12.68)
+ .023409183 (R1) -.45947147 (R2) -.21077640 (R3) -.27349921 (R5)
(.45) (8.64) (3.35) (5.66)

F - VALUE: 100.92237

r :.89347

r^2 :.79830

STANDARD DEVIATION:0.19114

N OF CASES: 160

COMMENTS: IRATLN = Log of freight rate per ton
LSIZE = Shipment lot size
DISTSQ = Square root of distance
R1 = Origin U.S. Great Lakes = 1, otherwise = 0
R2 = Origin St. Lawrence Seaway = 1, otherwise = 0
R3 = Origin U.S. North of Hatteras = 1, otherwise = 0
R5 = Origin U.S. Gulf = 1, otherwise = 0

Note: No shipments out of the South Atlantic. Dummy variable R4 was statistically insignificant (i.e., R4 = 0) when all other independent variables were included.

OCEAN BULK CHARTER RATES - FUNCTIONAL RELATIONSHIPS

FOREIGN AREAS: All

U.S. AREAS: All

COMMODITIES: Ores and miscellaneous bulk materials

FUNCTION: IRATLN = -125.37318 (DISTIS) -.60406930 (LSIZELN) + 10.183179
(10.27) (9.44)

F - VALUE: 129.62653

r :.92922

r^2 :.86345

STANDARD DEVIATION: .33098

N OF CASES: 44

COMMENTS: IRATLN = Log of charter rate per ton
DISTIS = Inverse of square root of distance
LSIZELN= Log of lot size in tons

APPENDIX G(57)

RATE CALCULATOR EQUATIONS

OVERLAND RATES

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Rail

COMMODITY: General cargo

FUNCTION: IRATLN =.48615138(DISTLN)+.11966509(VALTLN)+.0010097537(ISTOW)
(10.03) (6.32) (5.75
+.47914772(COMM)+.14950108(TAR1)-.33718811(TAR2)-.19722556
(11.25) (1.82) (5.01) (3.90) (TAR3)
+.75889719

F - VALUE: 113.93658

r : .83991

r^2 : .70545

STANDARD DEVIATION: .33781

N of Cases = 341

N OF CASES:

COMMENTS:

IRATLN = Log of freight rate in cents per CWT
VALTLN = Log of value per ton
ISTOW = Stowage x 100
COMM = Class rate = 2
Commodity rate = 1
TAR1 = Tariff area 1
TAR2 = Tariff area 2
TAR3 = Tariff area 3

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Rail

COMMODITY: FAK containers

FUNCTION: IRAT =.15519916(DIST)-13.010257(PLAN)-48.503711(TAR3)
(19.40) (2.45) (7.81)

-52.110426(TAR2)-4.6969617(TAR1)+101.46927
(4.28) (.30)

F - VALUE: 318.12525

r : .96288

r^2 : .92714

STANDARD DEVIATION: 26.87659

N OF CASES: = 131

COMMENTS:

NOTE: In cases where rates were given per trailerload (TL), conversion to cents/cwt were performed using 14LT/TL. This conversion factor was derived through trial and error, and it gave best correlation.

IRAT = Rate, cents per cwt
PLAN = Plan 2-1/2 = 1
Plan 3 = 2
TAR3 = Tariff area 3 = 1, otherwise = 0
TAR2 = Tariff area 2 = 1, otherwise = 0
TAR1 = Tariff area 1 = 1, otherwise = 0

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Rail, Tankcar

COMMODITY: Petroleum products

FUNCTION:

$$\text{IRATLN} = \underset{(6.75)}{.53485938}\ (\text{DISTLN}) - \underset{(3.11)}{1284.4748}\ (\text{VALTI3}) - \underset{(3.09)}{.41573745}\ (\text{TAR2}) - \underset{(2.53)}{.50395562}(\text{TAR3}) + 2.1735438$$

F - VALUE: 17.12782

r : .81751

r^2 : .66833

STANDARD DEVIATION: .31481

N OF CASES: = 39

COMMENTS:

IRATLN = Log of rate (cents/cwt)
DISTLN = Log of distance in miles
VALT = Value per ton
VALTP3 = $\text{VALT}^3/100$
VALTI3 = 1/VALTP3
TAR2 = Tariff area 2 = 1, otherwise = 0
TAR3 = Tariff area 3 = 1, otherwise = 0

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Rail, single carload rates*

COMMODITY: Coal

FUNCTION: IRAT = .072436205 (DIST) - 11.282120 (TAR3)+25.552783
(16.50) (4.39)

F - VALUE: 136.22117

r : .89589

r^2 : .80262

STANDARD DEVIATION: 8.67306

N OF CASES: = 70

COMMENTS:

IRAT = Rate in cents per cwt
DIST = Distance in miles
TAR3 = Tariff area3 = 1, otherwise = 0

---

* Appendix F describes the methodology for developing multiple-car freight rates.

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Rail

COMMODITY: All other bulks except coke

FUNCTION: IRATLN = .36684549 (DISTLN) + .28817356 (GRAV) -.49413439 (TAR4) -.23189879 (VALTIS) + 2.1914052

(12.13) (5.86) (2.52) (2.47)

F - VALUE: 66.31862

r : .87025

r^2 : .75733

STANDARD DEVIATION: .19039

N OF CASES: 90

COMMENTS: IRATLN = Log of freight rate
DISTLN = Log of distance
GRAV = Gravity flow = 1
Nongravity flow = 2
TAR4 = Tariff area 4
VALTIS = Inverse of square root of value per ton

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Rail

COMMODITY: Coke

FUNCTION: IRAT = 12.668412 (DISTLN) -19.206990
(5.61)

F - VALUE: 31.43800

r : .83180

r^2 : .69189

STANDARD DEVIATION: 3.99292

N OF CASES: 16

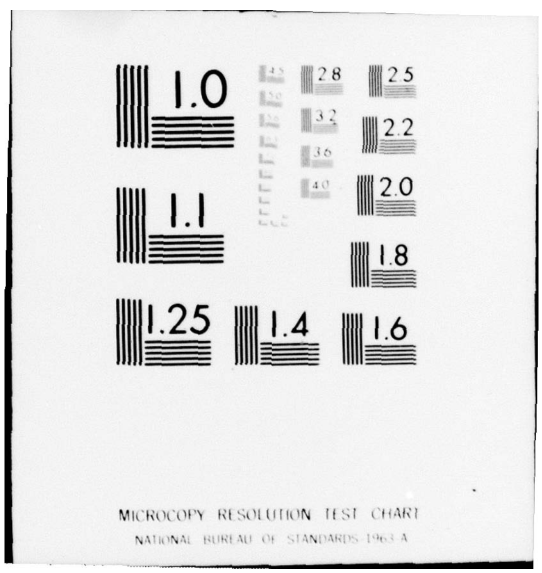
COMMENTS: IRAT = Freight rate in cents per weight
DISTLN = Log of distance

AD-A054 630 BOOZ-ALLEN AND HAMILTON INC BETHESDA MD F/G 15/5
DEVELOPMENT OF A LOGISTICS PRICE FILE.(U)
OCT 77

UNCLASSIFIED NL

3 OF 3
AD
A054630

END
DATE
FILMED
7 -78
DDC


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0
MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Truck

COMMODITY: General cargo

FUNCTION: IRAT = .24306390 (DIST) + 66.467060 (COMM) +.27220376 (ISTOW)
(24.25) (8.30) (6.81)
-77.329878

F - VALUE: 265.43307

r : .89762

r^2 : .80573

STANDARD DEVIATION: .27155

N OF CASES: 196

COMMENTS: IRAT = Freight rate cents/cwt
COMM = Class rates = 2
Commodity rates = 1
ISTOW = (Stowage factor MT/LT)*100
DIST = Distance in miles

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Truck

COMMODITY: FAK containers (size above 26.5 ft)

FUNCTION: IRAT = .2219 (DIST) + 77.23
(16.66)

F - VALUE: 277.50646

r : .92051

r^2 : .84753

STANDARD DEVIATION: 35.02178

N OF CASES: 53

COMMENTS: IRAT = Freight rate in cents per cwt.
DIST = Distance in miles

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Pipeline

COMMODITY: Crude petroleum

FUNCTION: IRATIN = -.01245814 (DISTLN) +.10968167
(7.33)

F - VALUE: 53.79103

r : .89742

r^2 : .80536

STANDARD DEVIATION: .00496

N OF CASES: 15

COMMENTS: IRATIN = Inverse of freight rate in cents per barrel
DISTLN = Log of distance

NOTE: The tariffs did not identify pipeline diameter.

OVERLAND RATES - FUNCTIONAL RELATIONSHIPS

MODE: Pipeline

COMMODITY: Refined petroleum products

FUNCTION: IRAT = 18.768822 (DISTLN) + 37.282501 (TAR1) -65.697971
(4.75) (4.14)

F - VALUE: 61.80809

r : .86921

r^2 : .75553

STANDARD DEVIATION: 20.30255

N OF CASES: 43

COMMENTS: IRAT = Rate expressed in cents per barrel
TARL = Origin U.S. Gulf = 1, otherwise = 0

NOTE: The tariffs did not identify pipeline diameter.